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PLUTONIUM, AMERICIUM, AND URANIUM IN BLOW-SAND MOUNDS OF SAFETY-SHOT SITES AT THE NEVADA TEST SITE AND THE TONOPAH TEST RANGE

by

E. H. Essington, R. O. Gilbert, D. L. Wireman,
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ABSTRACT

Blow-sand mounds or miniature sand dunes and mounds created by burrowing activities of animals were investigated by the Nevada Applied Ecology Group (NAEG) to determine the influence of mounds on plutonium, americium, and uranium distributions and inventories in areas of the Nevada Test Site and Tonopah Test Range. Those radioactive elements were added to the environment as a result of safety experiments of nuclear devices.

Two studies were conducted. The first was to estimate the vertical distribution of americium in the blow-sand mounds and in the desert pavement surrounding the mounds. The second was to estimate the amount or concentration of the radioactive materials accumulated in the mound relative to the desert pavement.

Five mound types were identified in which plutonium, americium, and uranium concentrations were measured: Grass, Shrub, Complex, Animal, and Diffuse. The mound top (that portion above the surrounding land surface datum), the mound bottom (that portion below the mound to a depth of 5 cm below the surrounding land surface datum), and soil from the immediate area surrounding the mound were compared separately to determine if the radioactive elements had concentrated in the mounds.

Results of the studies indicate that the mounds exhibit higher concentrations of plutonium, americium, and uranium than the immediate surrounding soil. The type of mound does not appear to have influenced the amount of the radioactive material found in the mound except for the Animal mounds where the burrowing activities appear to have obliterated distribution patterns.

INTRODUCTION

Since 1972 the Nevada Applied Ecology Group (NAEG) has been estimating inventories of radioactive material at the Safety Shot sites at the Nevada Test Site (NTS) and the Tonopah Test Range (TTR) in southcentral Nevada. The early studies of inventory were conducted without consideration of small local features such as drainage ways, blow-sand mounds, and the mounds created or added to by the digging of burrowing animals. It was recognized that the mounds could accumulate resuspended radioactive materials that originated from safety tests of nuclear devices thereby influencing the estimates of inventory.

Estimates of inventory are presented by Gilbert *et al.* (1975) pertaining to the top 5 cm of soil; those inventories considered mounds on the same basis as the desert pavement area surrounding the mounds. Questions remained, however, as to the amount of radioactive material present in the interior of the mound below the 5 cm depth. As a result, Mound Studies 1 and 2 were initiated to determine the impact of mounds on calculated inventories. Mound Study 1 was a preliminary study to provide information for the design of Mound Study 2, and to provide an estimate of the vertical distribution of ^{241}Am in typical mounds. Mound Study 2 was designed to estimate the inventory of ^{239,240}Pu, ^{241}Am, and uranium present in mounds to a depth of 5 cm below the level of the surrounding desert pavement. This estimate could then be added to a separate estimate of the inventory to a depth of 5 cm in desert pavement to yield a total inventory that would include that radioactive material in the interior of the mound. Those estimates and the statistical methods used to obtain the estimates are given by Gilbert and Essington (1978, elsewhere in this document)

The present paper describes in various ways the data from Mound Studies 1 and 2 and investigates the relationship between concentrations and total amounts of ^{239,240}Pu, ^{241}Am, and total uranium in mounds, under mounds, and in surrounding desert pavement. Also presented are data describing changes in ^{239,240}Pu to ^{241}Am ratios over time, instrumental measurements of ^{241}Am taken over mounds and over surrounding desert pavement, estimates of the area covered by mounds of various types, and vertical distributions of ^{241}Am in mounds and surrounding desert pavement.

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DESCRIPTION OF MOUNDS

Blow-sand mounds are minature sand dunes found in great numbers distributed over the NTS and TTR areas. Apparently the mounds were formed by the accumulation of the predominantly sand-sized particles suspended by wind from the surrounding area or by the action of small burrowing mammals. Initiation, growth, and stability of the mounds are not well understood but are important factors in evaluating the movement and distribution of radioactive materials at the Safety Shot sites. For example, new mounds may form accumulating resuspended radioactive material and/or old mounds may move to cover the radioactive material deposited a number of years earlier. Such action could reduce the amount of radioactive material available for resuspension. Mounds may also provide the conditions necessary for radioactive materials to become more available for uptake by the local vegetation since most of the plants in the area appear to be growing in the mounds.

In some areas blow-sand mounds are absent, but in other areas a substantial portion of the area is covered with mounds. Mound cover estimates reported by Gilbert and Essington (1978) for Project 57 in Area 13 of NTS and for Clean Slate 3 in Area 52 of TTR are 17% and 31%, respectively, as shown in Table 1.

Five types of mound-like features were identified during site visits to TTR and NTS. These types are Grass, Shrub, Complex, Animal, and Diffuse.[1] The estimated area covered by each of the five types of mounds is shown in Table 1 for Project 57 and Clean Slate 3. The Grass mound (Fig. 1) is a small, lone mound, generally 10-15 cm diam and 1-3 cm high, and is associated with a small clump of grass such as Indian rice grass (*Oryzopsis hymenoides*). Grass mounds were well represented at the Clean Slate 3 site, but were not in evidence at the Project 57 site. The Shrub mound (Fig. 2) is a small, lone mound associated with a single shrub plant. Shrub mounds are generally larger than Grass mounds, measuring 25-30 cm diam and 3-5 cm high. The Complex mound (Fig. 3) is a large feature 0.5 to 2 m across, generally of irregular shape, and 5 to 20 cm high. Complex mounds are distinguished from other mounds primarily by the presence of more than one specie of vegetation, including grasses. The Animal mound (Fig. 4) is categorized separately, but may include features of the Shrub or Complex mounds. Animal mounds are usually large, consisting of a single large burrow or several small burrows. In the act of digging the burrows, the animal brings soil to the surface thereby creating a mound or adding soil to the top of an already established mound. The vegetation species associated with the Animal mounds is generally similar to that of the Shrub or Complex mounds. Another type of Animal mound was observed and appeared to have supported a large colony of small animals. The large colony-type mounds were not included in the mound studies since they are few in number and their combined influence on radioactive material inventory was expected to be very small. Diffuse mounds (Fig. 5), do not appear to be discrete mounds as were identified for the other mound types. A diffuse mound is a low, flat, extensive feature from less than one to many meters across and usually from less than one to several centimeters high. Many small, grass tufts grow throughout the mound area. The material in the Diffuse mounds is predominantly fine sands as opposed to the surrounding desert pavement.

MOUND STUDY 1

Two studies were conducted on mound characteristics. Mound Study 1 (MS-1) was to provide information on the vertical distribution of ^{241}Am in the mound and in the desert pavement material surrounding the mound. This information was needed to provide guidance for a more comprehensive study, designated Mound Study 2 (MS-2), which was to estimate the mound's contribution to ^{239,240}Pu, ^{241}Am and uranium inventories.

Description

Mound Study 1 was conducted during September and October of 1974 at Site C in Area 11 of NTS. Although some aspects of MS-1 have been reported previously (Brady, 1974, and Gilbert *et al.*, 1975), it is included in this report to provide continuity for the MS-2 effort.

A 100-ft by 100-ft (30.5-m by 30.5-m) square plot was selected within an undisturbed area at Site C in Area 11 (Fig. 6). This plot was in an area of sufficient ^{241}Am radioactivity so that collected samples could be readily analyzed using Ge(Li)[1] counting techniques. Ten sampling points were randomly selected from which a desert pavement profile and a mound profile were collected. The mound closest to the desert pavement location was selected for sampling. Figure 7 shows the relative locations of the mound and desert pavement profiles. Samples were collected by the trench method (Fowler *et al.*, 1974), resulting in ten 2.5-cm thick increments for each profile and a total sampled depth of 25 cm. A number of descriptive measurements, not included in this report, were made to describe the location, height, width, length, and elevation of each mound, and to describe the location of the profiles

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[1]Ge(Li) - lithium drifted germanium gamma radiation detector used with a pulse height analyzer counting system.

(Brady, 1974). The vegetation growing on each mound was also collected in total, identified, and assayed for ^{241}Am.

Results

Table 2 summarizes the ^{241}Am found in the profiles and vegetation samples. Note that the depth of ^{241}Am penetration in the desert pavement was generally less than that found in the mound profiles. On the average, ^{241}Am penetrated to a depth of 20 cm below the surface of the mound while in the desert pavement the penetration averaged only 14 cm. The stated depth of penetration is based on the point at which the amount of ^{241}Am in the sample fell below the detection limit of the Ge(Li) counting system; this does not imply that small amounts of ^{241}Am had not penetrated to greater depths. Note also that most of the ^{241}Am was located in the top 2.5-cm fraction of the desert pavement profiles. On the average, the top 2.5-cm fraction contained 86% of the total profile ^{241}Am. On the other hand, the top 2.5 cm and 5 cm of the mound contained 49% and 82% of the total profile ^{241}Am, respectively, indicating a wider distribution of ^{241}Am with depth in the mound. Mound No. 8 appears to represent an extreme case of ^{241}Am distribution with only 17% of the ^{241}Am in the top 2.5 cm. Figure 8 represents the distribution of ^{241}Am in both mound and desert pavement profiles for Mound No. 8. When the mound profile was adjusted vertically so that the desert pavement datum of each profile was aligned, one could see that there was a substantially larger amount of ^{241}Am in the mound than in the desert pavement. The distribution of the ^{241}Am suggests that the mound had accumulated substantial quantities of ^{241}Am, probably from the surrounding area. Additional information on the profiles collected for MS-1 is presented in Appendix A.

Table 2 lists the ^{241}Am levels found in the vegetation collected from each mound. Americium-241 levels in the vegetation do not correlate well with ^{241}Am levels in total mound profile or with ^{241}Am levels in either the mound or desert pavement. These observations are consistent with the poor correlation of $^{239,240}Pu$ in soil and vegetation pairs at the Safety Shot sites reported by Romney *et al.* (1974 and 1975).

The above observations indicate that the mound features at Site C in Area 11 accumulated ^{241}Am. Presumably a similar effect occurred at other sites where similar types of mounds were present. Plutonium is expected to be similarly affected.

MOUND STUDY 2

Mound Study 2 was initiated to determine the degree to which mounds would alter radioactive material inventories which had already been estimated for Safety Shot sites. Project 57 in Area 13 at NTS, and Clean Slate 3 in Area 52 at TTR were chosen for the study because of the relatively large proportions of these areas which are covered by mounds and because estimates of $^{239,240}Pu$ and ^{241}Am inventories had already been made for these areas.

Description

Two study plots, each 100-ft by 100-ft (30.5-m by 30.5-m) square, were located within each stratum at each site for a total of 20 plots--12 at Project 57 and 8 at Clean Slate 3. Figure 9 shows the locations of the plots at Project 57 relative to the FIDLER[1] radioactivity strata derived for estimations of inventory (Gilbert, 1975). Figure 10 shows the plot locations for Clean Slate 3. For the most part, the plots were placed at randomly selected locations; however, an effort was made to avoid placing plots adjacent to each other or in areas where significant terrain alteration had occurred. For instance, no plots were located that intersected roads, structures, or construction material dumps. Also, the two plots in stratum 4 of Clean Slate 3 were placed outside the inner fence surrounding the ground zero area, since extensive physical disturbance had occurred within the fenced area (Fig. 10).

Each plot was divided into four equal quadrants, 50-ft by 50-ft (15-m by 15-m). One randomly selected quadrant was divided into quadrates of 10-ft by 50-ft (3-m by 15-m), as shown in Appendix B, Fig. B-1. Two mounds of each of the five types represented (Grass, Shrub, Complex, Animal, and Diffuse) were chosen at random within each quadrant (Appendix B, Fig. B-2). Length, width, and height measurements were made on each of the randomly selected mounds to estimate the base area and volume of each mound (Refer to Appendix B, Fig. B-3, for the types of measurements made). These dimensions and the total number of each type of mound that fell within the quadrant boundary were determined for the purpose of estimating the proportion of area covered by mounds (see Gilbert and Essington, 1978). Vegetation was completely removed from the top of the mound and retained for analysis; sections of the trunk or stem of the shrubs were collected for future use in dating the age of the mound.

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[1]FIDLER - Field instrument for the detection of low energy radiation. Responds to the 60 keV gamma emmision of ^{241}Am.

FIDLER measurements were obtained from the mound after the vegetation was removed, from underneath the mound after the top of the mound was removed to the desert pavement datum, and from the desert pavement sampling point. All FIDLER measurements were made at a height of 1 ft above the soil surface at each sampling point. These measurements were made to determine the utility of the FIDLER in detecting differences in mound and desert pavement radiation levels. Techniques for the FIDLER measurements and results are given in Appendix C.

Vegetation was removed, and three soil samples were collected from each chosen mound location. First, a Desert Pavement (DP) sample was collected just north and in a line through the mid-point of the mound perpendicular to the long axis of the mound; this is designated "SPXR" in Fig. B-3 of Appendix B. The DP sample was collected with a 12.7-cm diam by 5-cm deep sampling ring placed so that the edge of the ring nearest to the mound was 10 cm from the edge of the mound. A second soil sample consisted of the entire top of the mound (MT) collected to the desert pavement (land surface) datum. The third soil sample was the mound bottom (MB), represented by that material within the boundary of the mound to a depth of 5 cm below the desert pavement datum. These types of samples were collected from the Grass, Shrub, Complex, and Animal mounds.

The Diffuse mounds were sampled differently. Each mound was sketched to scale on coordinate paper in order to divide the mound into a number of sections as shown in Appendix B, Fig. B-4. Up to four of the coordinate squares were located by random selection which represented the sampling points. A DP sample was collected opposite each of the four points at a distance of 10 cm from the edge of the mound as was done for the other types of mounds. The MT was sampled using the 12.7-cm diam by 5-cm deep ring; the sample was taken to the desert pavement datum. The MB sample was similarly collected, using the ring to a depth of 5 cm below the desert pavement datum, according to the procedure reported by Fowler *et al.*, (1974).

Some of the MT and MB samples were quite large--too large to process using the established NAEG technique of direct ball-milling in 1-gal paint cans. The largest samples were weighed in the field, placed in a plastic lined concrete mixer, mixed, and a weighed subsample was retained. Other large samples were collected *in toto* and subsampled in the preparation laboratory. These samples were weighed, placed in a plastic bag, mixed by kneeding, then a weighed subsample was retained. The kneeding procedure was tested on radioactive soil materials similar to those of the mound study areas. A number of aliquots of ball-milled material were assayed for ^{241}Am and compared with similar assays of a combination of non-radioactive and radioactive materials mixed by kneeding. An "F-test" (Snedecor and Cochran,

1967) revealed that the variances of he two populations of ^{241}Am values were not statistically different supporting the hypothesis that kneeding adequately mixed the soils.

Most samples were analyzed for ^{241}Am by the Ge(Li) method; ^{241}Am on the lower activity samples and ^{239,240}Pu on all samples were determined by radiochemical separation and alpha spectrometry. Total uranium was determined by the fluorometric method. As yet, no analyses on vegetation samples have been authorized.

The above sampling scheme was chosen to provide a number of paired observations on a random basis. The variability in mound to desert pavement radioactivity ratios should be less using paired rather than unpaired data.

<u>Results</u>

Since both ^{239,240}Pu and ^{241}Am were measured on the same aliquot taken from each sample, their ratio and linear regression relationships were examined. This evaluation was made to detect possible outliers, which could have resulted from the analytical and data transfer processes. Figure 11 is a typical plot of ^{239,240}Pu vs ^{241}Am for the pooled DP, MT, and MB results for Clean Slate 3 Grass mounds. Note that the fit of a linear regression line is quite good resulting in an estimated slope of 20 with a correlation coefficient near unity. Similar fits were observed for the Shrub, Complex, and Animal mounds. In contrast, Fig. 12 shows the ^{239,240}Pu vs ^{241}Am for pooled DP, MT, and MB of the Diffuse mounds. The data show considerable scatter, but when a selected 20 of the 160 data points are discarded, a linear regression line yields a slope and correlation coefficient consistent with those of the other mound types. Certain data points in Fig. 12 tend to suggest another distribution of ^{239,240}Pu and ^{241}Am, as shown across the bottom of the figure. No physical mechanism was apparent at Clean Slate 3 that could account for either the poor correlation of ^{239,240}Pu and ^{241}Am or a possible second radioactive material distribution. Table 3 gives the average ratios ($\bar{R}$) for each site, mound type, and sample type. The average ratio is computed as the ratio of the means of ^{239,240}Pu and ^{241}Am, S.E. is the calculated standard error, and r is the estimated correlation coefficient. Note that almost all of the ratios, except for Diffuse mounds, fall around 20 for Clean Slate 3 and about 6 for Project 57 and have correlations near unity. There appears to be no dependence of the ratios on the sample type (DP, MT, MB), or on mound type (Grass, Shrub, *etc.*), or on stratum number.

The ^{239,240}Pu to ^{241}Am ratios are also summarized in Table 4, where the median ratio and its 95% confidence limits are given for the Clean Slate 3 and Project 57 sites for both MS-2 and the initial soil inventory sampling program in 1972. It is clear that the $^{239,240}Pu$ to ^{241}Am ratios have changed over time at both sites, but that the change in average ratio at Project 57 was greater than at Clean Slate 3. Part of the change in $^{239,240}Pu$ to ^{241}Am ratios is due to the ingrowth of ^{241}Am from the ^{241}Pu known to contaminate the plutonium used in the experimental devices. If the $^{239,240}Pu$ to ^{241}Am ratio for Clean Slate 3 is 22.6 for the initial inventory (samples analyzed in early 1974), then the ratio predicted for MS-2 based on ^{241}Pu decay and ^{241}Am ingrowth only would be 20, which does approximate the ratio of 20.9 found for MS-2 (samples analyzed in mid 1976).[1] In this case the change in ratio is relatively well predicted by the ^{241}Am ingrowth. On the other hand, a similar test for Project 57 indicates that a ratio of 9.8 for the initial inventory (samples analyzed in mid 1973)[2] yields a ratio of 7.7 for MS-2. In this case there was too large a change in the observed ratio to be due only to ^{241}Am ingrowth. There was no apparent physical or environmental factor which could have accounted for this discrepency in $^{239,240}Pu$ to ^{241}Am ratio between the initial inventory in 1973 and MS-2 in 1976 at Project 57.

To summarize the many analytical results generated for MS-2, the ratios of MT to MB, MT to DP, and MB to DP were calculated. Table 5 lists the estimated MT to MB ratios of $^{239,240}Pu$, based on concentration (dis/min/g) for the various mound types with the respective standard errors (S.E.), medians (MED), and correlation coefficients (r). Almost all mound types, except the Animal and Diffuse mounds, exhibited a higher $^{239,240}Pu$ concentration in the MT relative to the MB; the ratio is near 2. The Animal mounds exhibited a ratio of near unity, which may have been due to the active mixing caused by the animal's burrowing. Material containing small amounts of radioactive material was brought to the surface, thereby diluting the higher concentration of radioactive material near the surface. As indicated previously, the Diffuse mound data suffered from considerable variability, however, the ratio of the average MT to MB concentration of 1.1 suggests that the Diffuse mounds were not as efficient collectors of radioactive particles as were the other mound types. Comparing the Shrub and Complex mounds at Clean Slate 3 with those at Project 57 indicates that there was no difference in the MT to MB ratios. Those two mound types appear to have been acting similarly in accumulating $^{239,240}Pu$ at the two sites.

A similar treatment of data was conducted for total uranium concentrations in MT and MB as shown in Table 6. Although the

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[1]Assuming, conservatively, that the plutonium fuel was produced in 1948.

[2]Assuming, conservatively, that the plutonium fuel was produced in 1957.

concentration of uranium increased toward the Clean Slate 3 ground zero, and did not at Project 57, the ratios are close to unity, which would be expected if the source of uranium were solely or predominantly from soil minerals. In all cases except for the Animal mounds, there was a slightly higher concentration of uranium in the MT relative to the MB. This may have been due to the accumulation of a fresh source of uranium in the new material deposited on the mound. Whether this source was local (in the range of meters) or regional remains unanswered. Again, the Animal mounds reflect the possible mixing or dilution of the MT, as was seen with the $^{239,240}Pu$.

There is an inherent problem in comparing MT to MB on the basis of concentration. The MB sample was collected to a depth of 5 cm below the desert pavement datum after the MT sample had been removed. All MB samples were larger (more massive) than MT samples so that whatever radioactive material was in the MB was diluted during sampling to a greater extent than the radioactive material in the MT sample. In other words, if the radioactive material represented by the MB was located near the desert pavement datum (near the top of the MB) considerable amounts of non-radioactive soil were incorporated into the MB sample generating an unknown degree of dilution. Because of this problem, further comparisons between MT, MB, and DP samples are made on the basis of the estimated projected surface area of the mound. Table 7 compares the MT to MB $^{239,240}Pu$ ratios based on the radioactivity per unit surface area. These ratios indicate that, although the concentration of $^{239,240}Pu$ was higher in the MT, the total amount of $^{239,240}Pu$ in either MT or MB was greater in the MB. The MT accounted for only 30% of the $^{239,240}Pu$ in the MT plus MB in all cases except the Complex mounds at Project 57. For purposes of inventory calculations, therefore, the amount of radioactive material in the MB should not be excluded.

A comparison of the amount of $^{239,240}Pu$ in the MT vs that in the top 5 cm of desert pavement (DP) is given in Table 8. On the basis of the amount of $^{239,240}Pu$ per unit land surface area, the MT accounted for considerably smaller amounts of $^{239,240}Pu$ than did the DP. This is consistent with the observations shown earlier in MS-1 profiles (Table 2), where the fraction of ^{241}Am in the top 2.5 cm and 5 cm of mounds was less than that for these increments in the adjacent desert pavement profiles.

Finally, a comparison $^{239,240}Pu$ in MB and DP is shown in Table 9. Except for Complex mounds at Clean Slate 3, the ratios are all near or slightly less than unity. Based on ±3 S.E. (99.7%) confidence limits the Complex mound ratios at Clean Slate 3 also bracket unity. Two postulates are presented regarding this observation. First, the MB may have been a remnant of desert pavement recently covered by the growth of the mound. The growth would have had to occur since the safety event nearly 20 yrs ago. Second, there may have been active leaching of the radioactive material that was deposited on the mound accumulating in the region of the mound bottom. Which of these postulates may be preferrable cannot be answered yet. However, the trunk portions of several of the shrubs have been collected for the purpose of age dating the vegetation. Perhaps these datings, where they can be determined, will lend credence to one or the other postulate..

A comparison was also made in order to investigate whether the vegetation species growing on the mound was related to the distribution of ^{239,240}Pu in the mound. For instance, did the shape or growth pattern of a plant influence the degree of particle deposition on the mound top, thereby having increased the MT to MB ratio? Also, did the shape or growth pattern influence the moisture reception and movement having increased the migration of radioactivity, thereby reducing the MT to MB ^{239,240}Pu ratios for Shrub mounds from both Clean Slate 3 and Project 57? The vegetation species associated with each ratio is noted as a letter code described at the bottom of the figure. Although *Atriplex confertifolia* and *Eurotia lanata* appear to concentrate around a ratio of 2, the scatter is so great and the numbers of other species represented is so small that no conclusion as to a ratio-species relationship can be drawn.

Since the ^{239,240}Pu to ^{241}Am ratios do not appear to depend on sample type (MT, MB, DP; see Table 3), the various mound and desert pavement ratios calculated for ^{239,240}Pu appear to adequately describe the probable ^{241}Am distribution in these same features. This can not be said of total uranium since it appears that additional factors were influencing the source of uranium in the mounds. Additional information relative to the distribution of the various ratios shown earlier are presented in Appendix B.

FIDLER measurements were obtained on mounds before and after the mound top was removed and on the adjacent desert pavement sampling locations before sampling. Results of these measurements are presented in Appendix C in Figs. C-1 through C-5 for Clean Slate 3, and Figs. C-6 and C-7 for Project 57. Measurements from each of the two replicate mounds in each plot were pooled. FIDLER responses were higher for strata closer to ground zero for all mound types. Except for the Animal mounds, the average FIDLER response over the mound was higher than the responses over desert pavement or over the soil after the MT sample was removed. The MT of the Animal mounds were generally lower than the MB or DP in FIDLER response. This observation is consistent with the possible mound disruption caused by the burrowing animals alluded to earlier.

The ^{241}Am radioactivity levels were generally too low in stratum 1 of Clean Slate 3 and strata 1 and 2 of Project 57 to have been adequately detected by the FIDLER. Therefore, no intercomparisons of MT, MB, or DP should be attempted for these strata. The FIDLER Observations do not appear to support the observations made in Tables 2 and 8 that smaller amounts of radioactive material were located in tops of mounds than in desert pavement areas at the Safety Shot sites. It is possible that the geometry of the FIDLER over the mound was distorted from that for the FIDLER over the desert pavement or mound bottom. Direct comparison of FIDLER readings for MT and MB or MT and DP probably should not be made.

Analysis of variance on the MS-2 data for Project 57 and Clean Slate 3 indicated statistically significant differences in average ^{239,240}Pu concentrations among MT, MB, and DP; between the two 50 ft by 50 ft square plots within each stratum; and between strata. No significant differences were detected, however, between average ^{239,240}Pu concentrations of the five mound types. The difference in ^{239,240}Pu concentrations between strata and between the two plots within the strata is not surprising since the general level of radioactivity is known to change with distance and orientation to ground zero at these sites (Gilbert *et al.*, 1975). These observations are discussed in more detail by Gilbert and Essington (1978).

SUMMARY

The results of MS-1 and/or MS-2 suggest the following:

1. The top portion of blow-sand mounds tend to have higher concentrations of ^{239,240}Pu and ^{241}Am than the mound bottoms or the surrounding desert pavement (top 5 cm).

2. Mound bottoms tend to have a greater total amount of ^{239,240}Pu and ^{241}Am associated with them than do mound tops.

3. Burrowing animals appear to have mixed the mound contents or diluted the mound surface so that the concentration of $^{239,240}Pu$ and ^{241}Am is relatively uniform between the mound top and mound bottom.

4. There seems to be no differential distribution of $^{239,240}Pu$ and ^{241}Am, at least when mound top and mound bottom are compared. The mound bottom may include a remnant of the desert pavement; the mounds may have formed or moved to their present locations since the Safety Shot events; or the mound bottom may be an effective receptor of $^{239,240}Pu$ and ^{241}Am leached from the mound top.

5. There seems to be no dependence of the distribution of $^{239,240}Pu$ or ^{241}Am in mounds on vegetation type or radioactivity stratum.

6. Ratios of $^{239,240}Pu$ to ^{241}Am are changing with time at both Clean Slate 3 and Project 57; the change at Project 57 since 1972 has been greater than at Clean Slate 3. Ingrowth of ^{241}Am from ^{241}Pu is found not to completely explain the degree of change in $^{239,240}Pu$ to ^{241}Am ratios at Project 57. The ratio change at Clean Slate 3 is about as great as would be predicted by ^{241}Am ingrowth.

7. Blow-sand mounds of various types cover about 17% and 31%, respectively, of the Project 57 and Clean Slate 3 study sites based on measuring a limited number of mounds at each site.

8. FIDLER readings tend to be higher over mounds than over desert pavement or over the soil after the mound top is removed.

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Table 1. Estimated Area Covered by Different Mound Types at Project 57 in Area 13 and at Clean Slate 3 in Area 52.[a]

Site	Mound Type	Estimated Area Covered by Mounds			
		m^2	S.E.[b]	%	S.E.[b]
Project 57	Shrub	61 000	15 000	1.5	0.42
	Complex	600 000	220 000	15	5.7
	Animal	600	130	0.015	0.003
Total		660 000	240 000	17	5.7
Clean Slate 3	Grass	21 000	6 400	1.2	0.37
	Shrub	43 000	8 100	2.5	0.47
	Complex	270 000	100 000	15	6.1
	Animal	9 400	6 000	0.54	0.35
	Diffuse	220 000	110 000	12	6.1
Total		560 000	[illegible]0 000	31	8.7

[a]Adapted from Table 10 of Gilbert and Essington (1978).

[b]Standard Error.

Table 2. Americium-241 in Mound, Desert Pavement, and Vegetation Samples from Site C in Area 11.

Mound Number	^{241}Am Penetration (cm)		Fraction of ^{241}Am in top 2.5 cm		Fraction of ^{241}Am in top 5.0 cm		^{241}Am in Vegetation	
	Mound	Desert Pavement	Mound	Desert Pavement	Mound	Desert Pavement	Species[a]	nCi/g dry wt.
1	20	10	0.65	0.94	0.67	0.99	H	0.65
2	22.5	17.5	0.42	0.90	0.85	0.93	M	1.1
3	25	17.5	0.49	0.86	0.83	0.94	C	0.21
4	22.5	7.5	0.48	0.84	0.83	0.98	C	0.19
5	22.5	22.5	0.65	0.81	0.95	0.84	M	0.12
6	20	12.5	0.29	0.95	0.91	0.99	C	0.24
7	12.5	10	0.86	0.99	0.99	0.99	H	0.24
8	20	17.5	0.17	0.64	0.29	0.97	C	0.19
9	25	12.5	0.47	0.97	0.98	0.99	E	0.33
10	12.5	12.5	0.46	0.74	0.92	0.99	C	0.82
$\overline{X}$	20	14	0.49	0.86	0.82[b]	0.96		0.41
S.E.	1	2	0.19	0.11	0.07[b]	0.02		0.10

[a]H = *Hymenoclea salsola*, M = *Menodore spinescens*, C = *Chrysothamnus viscidiflorus*, E = *Ephedra nevadensis*.

[b]$\overline{X}$ and S.E. (S. E. = standard deviation/$\sqrt{n}$) are 0.88 and 0.03, respectively, if datum 0.29 of Mound No. 8 is deleted.

Table 3. Ratio of Average $^{239,240}Pu$ to Average ^{241}Am for Mound Study 2.

Site / Mound Type / Sample Type	Number of Observ. (n)	Ratio of Averages ($\bar{R}$)	Standard Error (S.E.)[a]	Linear Correlation (r)
Clean Slate 3[b]				
Grass				
DP	14	21	2.2	0.99
MT	14	20	0.33	0.99
MB	14	20	0.23	0.99
Shrub				
DP	14	22	1.9	0.97
MT	12	18	1.6	0.96
MB	13	18	1.6	0.95
Complex				
DP	14	22	0.44	0.99
MT	14	29	3.2	0.86
MB	14	22	0.35	0.99
Animal				
DP	15	18	2.5	0.91
MT	13	21	1.4	0.99
MB	13	20	1.8	0.96
Diffuse				
DP	53	36	7.8	0.39
MT	54	11	1.7	0.31
MB	53	18	2.5	0.63
Project 57				
Shrub				
DP	20	5.8	0.072	0.99
MT	22	5.4	0.085	0.99
MB	22	5.5	0.17	0.99
Complex				
DP	21	5.7	0.15	0.99
MT	22	6.1	0.30	0.98
MB	20	5.6	0.10	0.99

[a] $S.E. = \{[\Sigma(y_i^2/x_i) - (\Sigma y_i)^2/\Sigma x_i]/(n-1)\,\Sigma x_i\}^{1/2}$.

[b] DP = Sample outside confines of the mound to a depth of 5 cm.

MT = Sample representing total top of mound collected to a datum defined by surrounding terrain.

MB = Sample below MT to a depth of 5 cm below same datum as that used for MT.

Table 4. Comparison of Median $^{239,240}Pu$ to ^{241}Am Ratios Found for the Initial Inventory with Those Found for Mound Study 2.

Site	Initial Inventory				Mound Study 2			
	n	Median[b]	95% Limits		n	Median	95% Limits	
			Lower	Upper			Lower	Upper
Clean Slate 3	69	22.6	22.0	23.7	262	20.9	20.6	21.4
Project 57	121[a]	9.8	9.1	10.1	144	5.8	5.7	6.0

[a]Excludes ratios for stratum 2 since $^{239,240}Pu$ and ^{241}Am concentrations were determined on separate aliquots for that stratum.

[b]Gilbert *et al.* (1975) reported average $^{239,240}Pu$ to ^{241}Am ratios (computed as mean Pu over mean Am concentration) as 22±0.25 (±S.E.) and 9.4±0.14 for Clean Slate 3 and Project 57, respectively.

Table 5. Distribution of $^{239,240}Pu$ in Mound Top (MT) and Mound Bottom (MB) Based on Concentration.

Mound Type	Number of Observ. (n)	Ratio: $\overline{MT}/\overline{MB}$[a]	Ratio: S.E.[b]	Ratio: Median	Linear Correlation (r)
<u>Clean Slate 3</u>					
Grass	16	1.9	0.24	2.1	0.88
Shrub	15	1.9	0.51	2.0	0.82
Complex	16	2.3	0.23	2.9	0.93
Animal	15	0.92	0.17	0.80	0.80
Diffuse	53	1.1	0.24	1.9	0.2[illegible]
<u>Project 57</u>					
Shrub	24	1.7	0.15	1.9	0.91
Complex	22	2.6	0.27	2.8	0.96

[a] $\overline{MT}$ = arithmetic mean of $^{239,240}Pu$ concentrations in MT samples; $\overline{MB}$ = arithmetic mean of $^{239,240}Pu$ concentrations in MB samples.

[b] S.E. computed as given in footnote of Table 3.

Table 6. Distribution of Total Uranium in Mound Top (MT) and Mound Bottom (MB) Based on Concentration.

Mound Type	Number of Observ. (n)	Ratio			Linear Correlation (r)
		$\overline{MT}/\overline{MB}$[a]	S.E.[b]	Median	
Clean Slate 3					
Grass	16	1.4	0.14	1.2	0.87
Shrub	16	1.4	0.16	1.3	0.78
Complex	16	1.3	0.16	1.3	0.67
Animal	15	0.84	0.053	0.80	0.86
Diffuse	53	1.6	0.12	1.4	0.78
Project 57					
Shrub	24	1.2	0.11	1.1	0.08
Complex	24	1.0	0.040	1.0	0.66

[a] $\overline{MT}$ = arithmetic of total uranium concentrations in MT samples;
$\overline{MB}$ = arithmetic of total uranium concentrations in MB samples.

[b] S.E. Computed as given in footnote of Table 3.

Table 7. Distribution of $^{239,240}Pu$ in Mound Top (MT) and Mound Bottom (MB) Based on Land Surface Area.

Mound Type	Number of Observ. (n)	Ratio $\overline{MT}/\overline{MB}$[a]	Ratio S.E.[b]	Ratio Median	Linear Correlation (r)
Clean Slate 3					
Grass	16	0.26	0.076	0.30	0.42
Shrub	15	0.26	0.069	0.25	0.76
Complex	16	0.36	0.071	0.50	0.77
Animal	15	0.31	0.056	0.39	0.86
Diffuse	53	0.35	0.10	0.44	0.11
Project 57					
Shrub	24	0.25	0.026	0.22	0.90
Complex	22	0.85	0.11	0.65	0.90

[a] $\overline{MT}$ = arithmetic mean of total amount of $^{239,240}Pu$ in MT samples per unit land surface area covered by mound;

$\overline{MB}$ = arithmetic mean of total amount of $^{239,240}Pu$ in MB samples per unit land surface area covered by mound.

[b] S.E. computed as given in footnote of Table 3.

Table 8. Distribution of ^{239,240}Pu in Mound Top (MT) and Desert Pavement (DP) Based on Land Surface Area.

Mound Type	Number of Observ. (n)	Ratio			Linear Correlation (r)
		$\overline{MT}/\overline{DP}$[a]	S.E.[b]	Median	
<u>Clean Slate 3</u>					
Grass	15	0.14	0.022	0.20	0.82
Shrub	15	0.28	0.065	0.31	0.76
Complex	16	0.77	0.14	0.70	0.72
Animal	14	0.15	0.036	0.32	0.60
Diffuse	53	0.33	0.12	0.58	0.07
<u>Project 57</u>					
Shrub	24	0.17	0.032	0.21	0.79
Complex	23	0.32	0.14	0.38	0.92

[a] $\overline{MT}$ = arithmetic mean of total amount of ^{239,240}Pu in MT samples per unit land surface area covered by mound;

$\overline{DP}$ = arithmetic mean of total amount of ^{239,240}Pu in DP samples per unit land surface area of samples.

[b] S.E. computed as given in footnote of Table 3.

Table 9. Distribution of $^{239,240}Pu$ in Mound Bottom (MB) and Desert Pavement (DP) Based on Land Surface Area.

Mound Type	Number of Observ. (n)	Ratio $\overline{MB}/\overline{DP}$[a]	Ratio S.E.[b]	Ratio Median	Linear Correlation (r)
Clean Slate 3					
Grass	16	0.83	0.10	0.81	0.92
Shrub	16	0.96	0.16	0.87	0.90
Complex	16	2.1	0.38	1.3	0.91
Animal	14	0.72	0.12	0.81	0.82
Diffuse	52	0.93	0.32	1.1	0.31
Project 57					
Shrub	24	0.69	0.11	1.0	0.93
Complex	21	0.80	0.16	0.76	0.88

[a] $\overline{MT}$ = arithmetic mean of total amount of $^{239,240}Pu$ in MT samples per unit land surface area covered by mound;

$\overline{LP}$ = arithmetic mean of total amount of $^{239,240}Pu$ in DP samples per unit land surface area of samples.

[b] S.E. computed as given in footnote of Table 3.

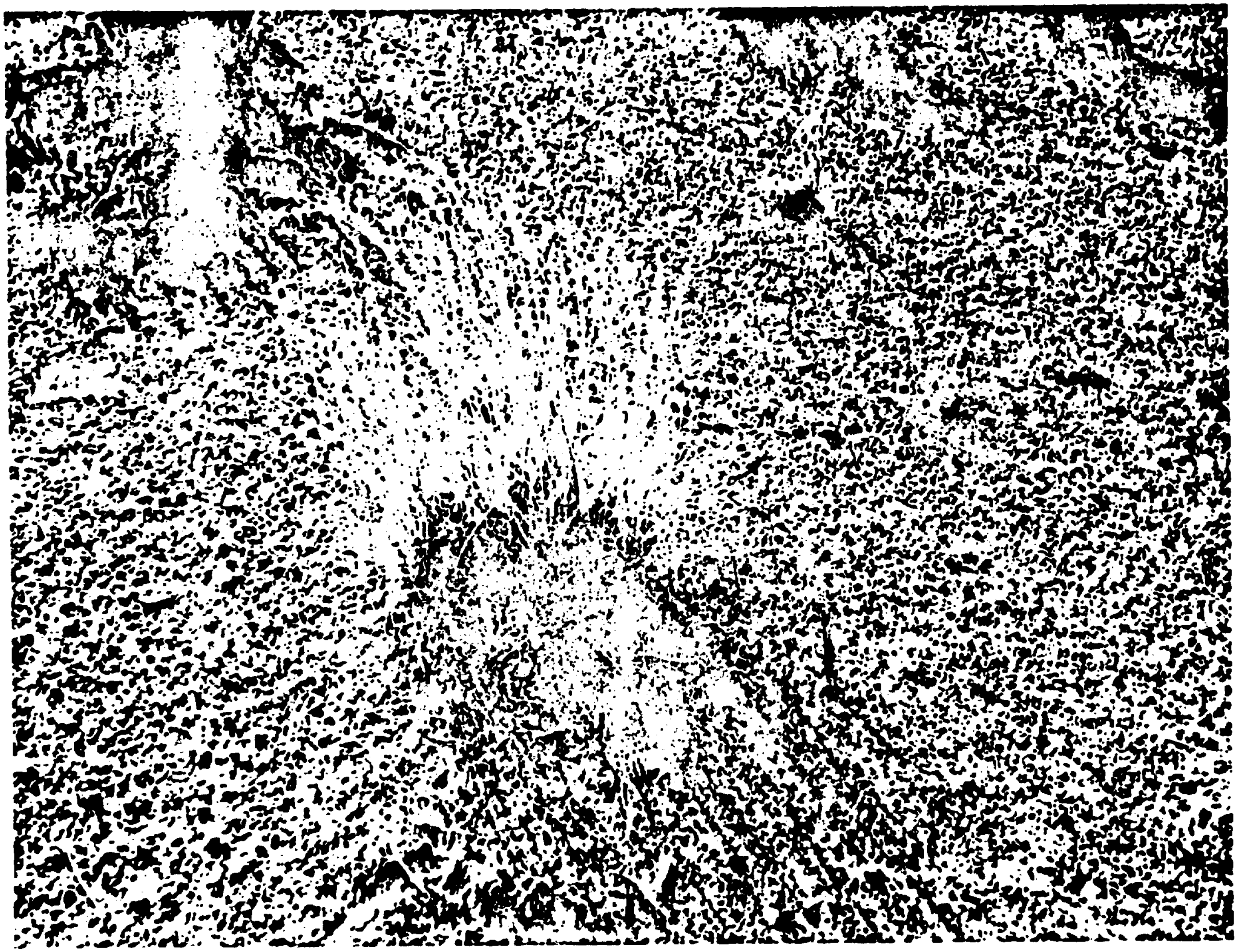


Fig. 1. Example of a Grass mound, Clean Slate 3 in Area 52, TTR.

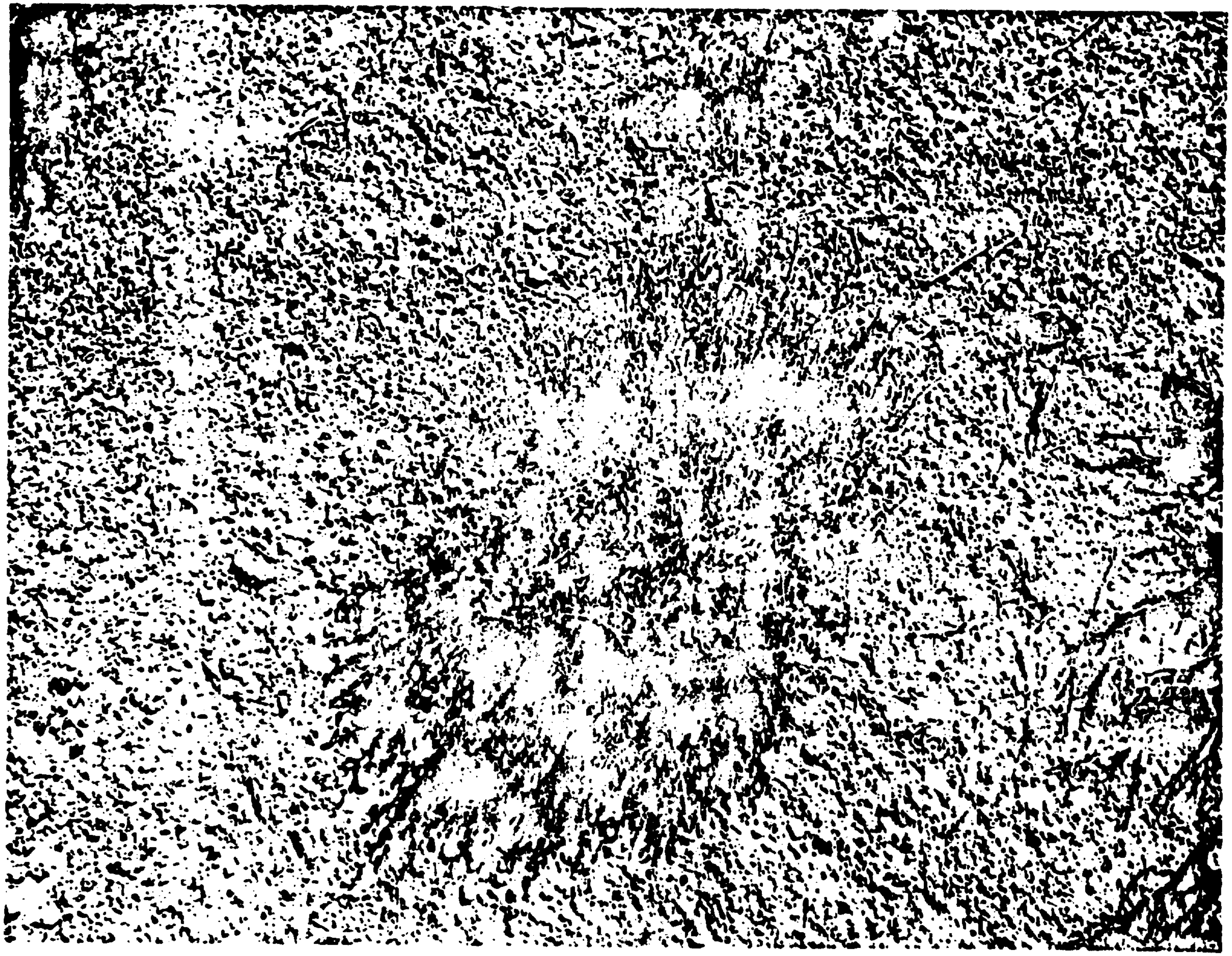


Fig. 2. Example of a Shrub mound, Clean Slate 3 in Area 52, TTR.

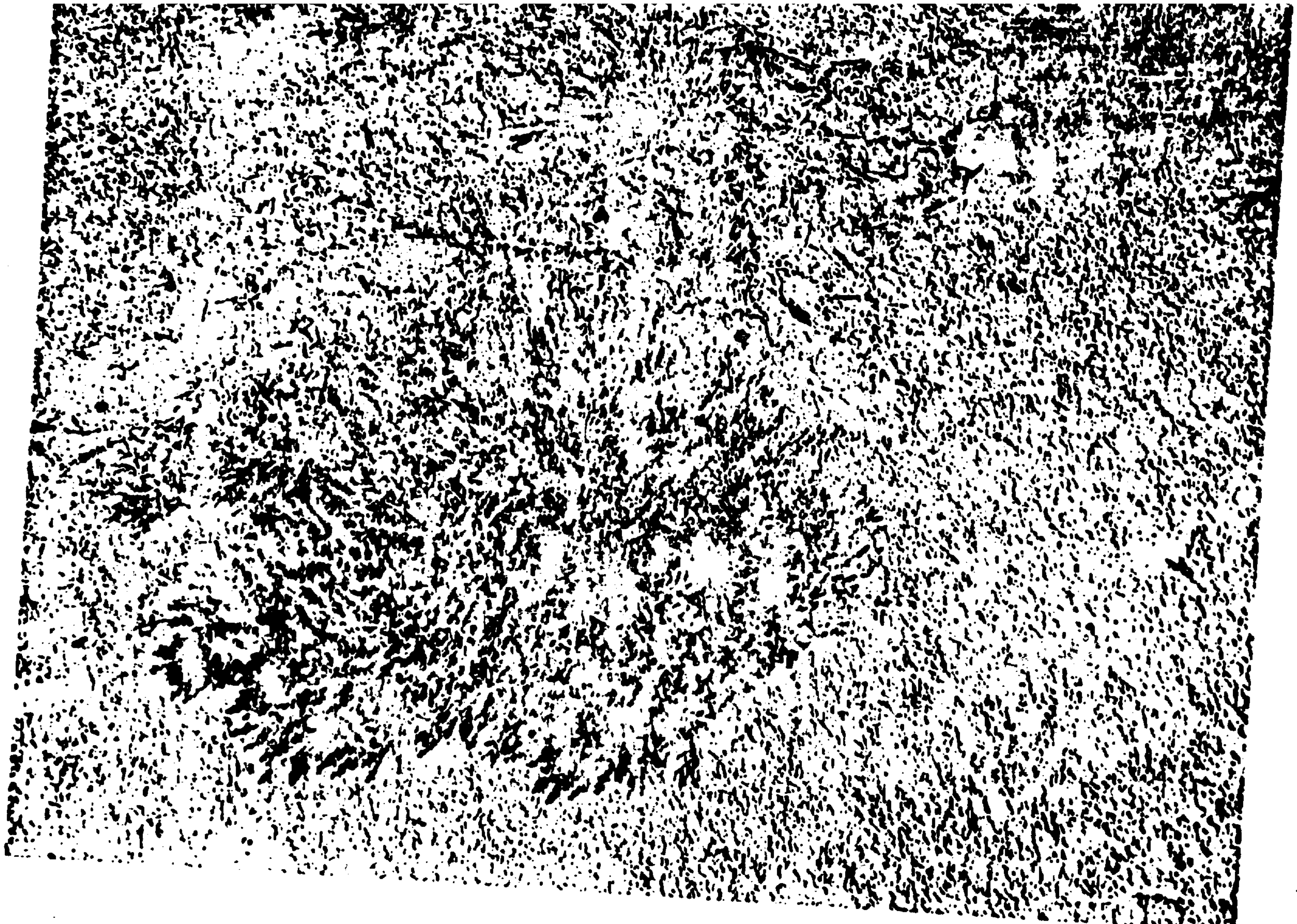


Fig. 3. Example of a Complex mound, Clean Slate 3 in Area 52, TTR. Note extension of mound toward top of photo.

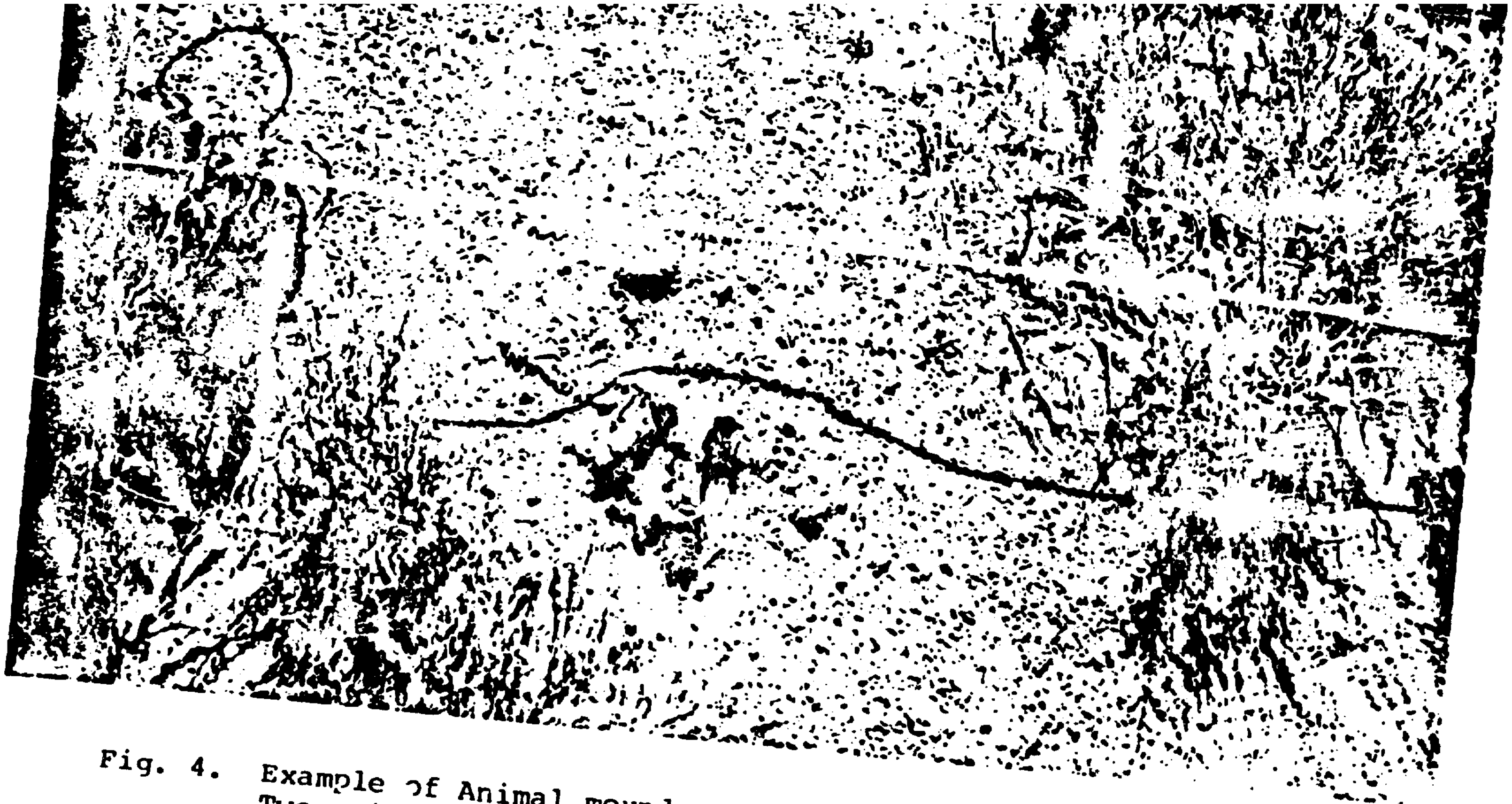


Fig. 4. Example of Animal mounds, Clean Slate 3 in Area 52, TTR. Two animal mounds are shown, one at the bottom-center of the photo and the other at the top-center.

Fig. 5. Example of a Diffuse mound at Clean Slate 3 in Area 52, TTR.
The mound is the area outlined by the rope.

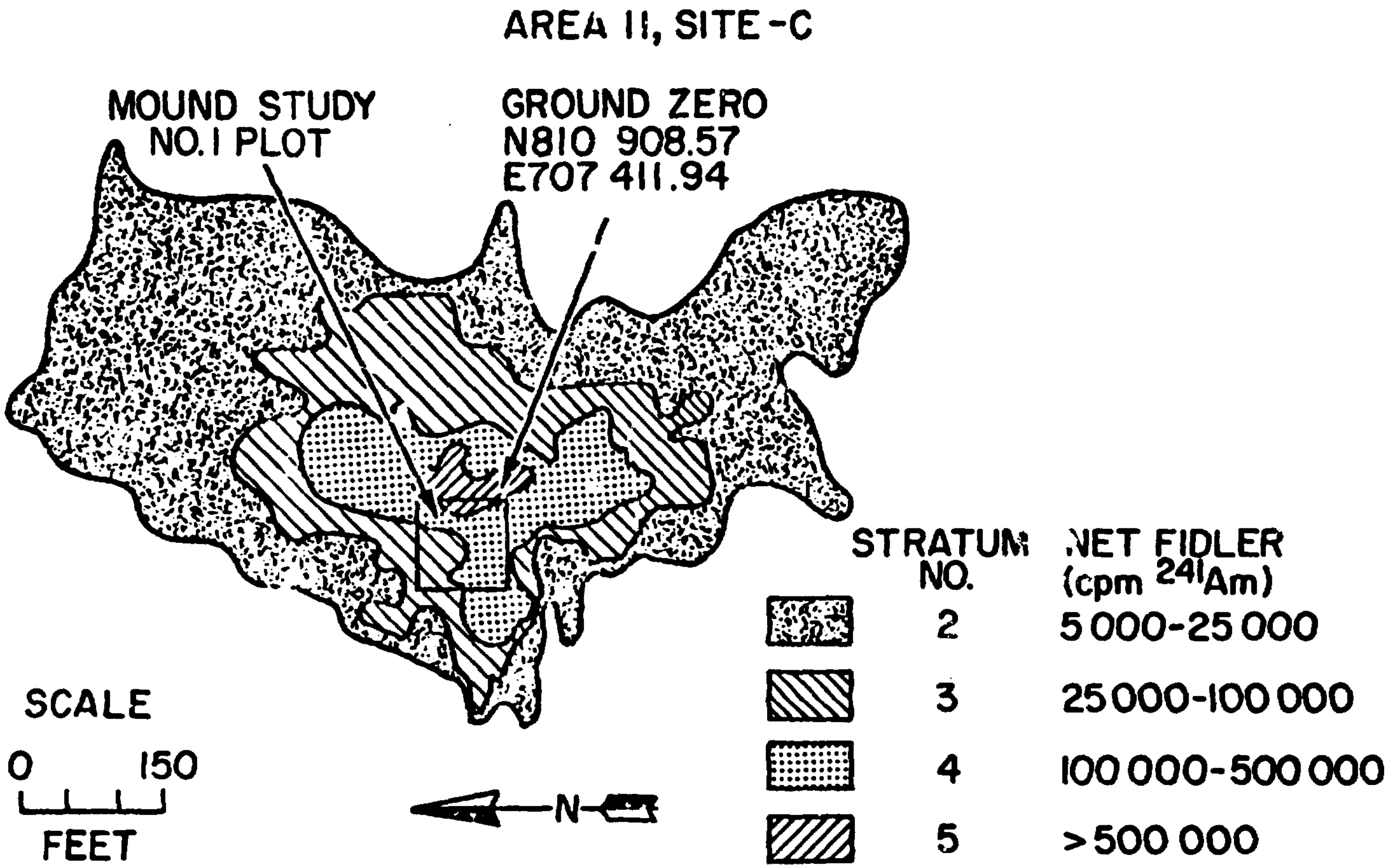


Fig. 6. Location of MS-1 plot relative to FILDER activity strata at Site C in Area 11.

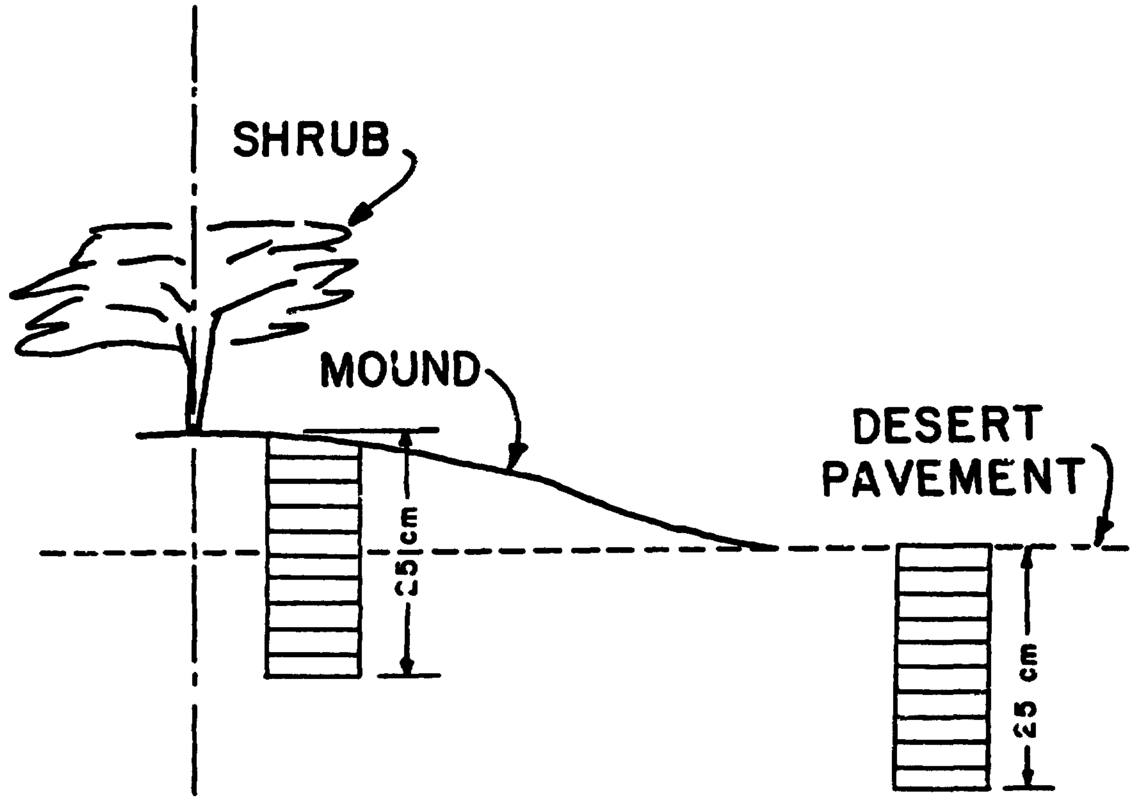


Fig. 7. Relative locations of mound and desert pavement soil profiles.

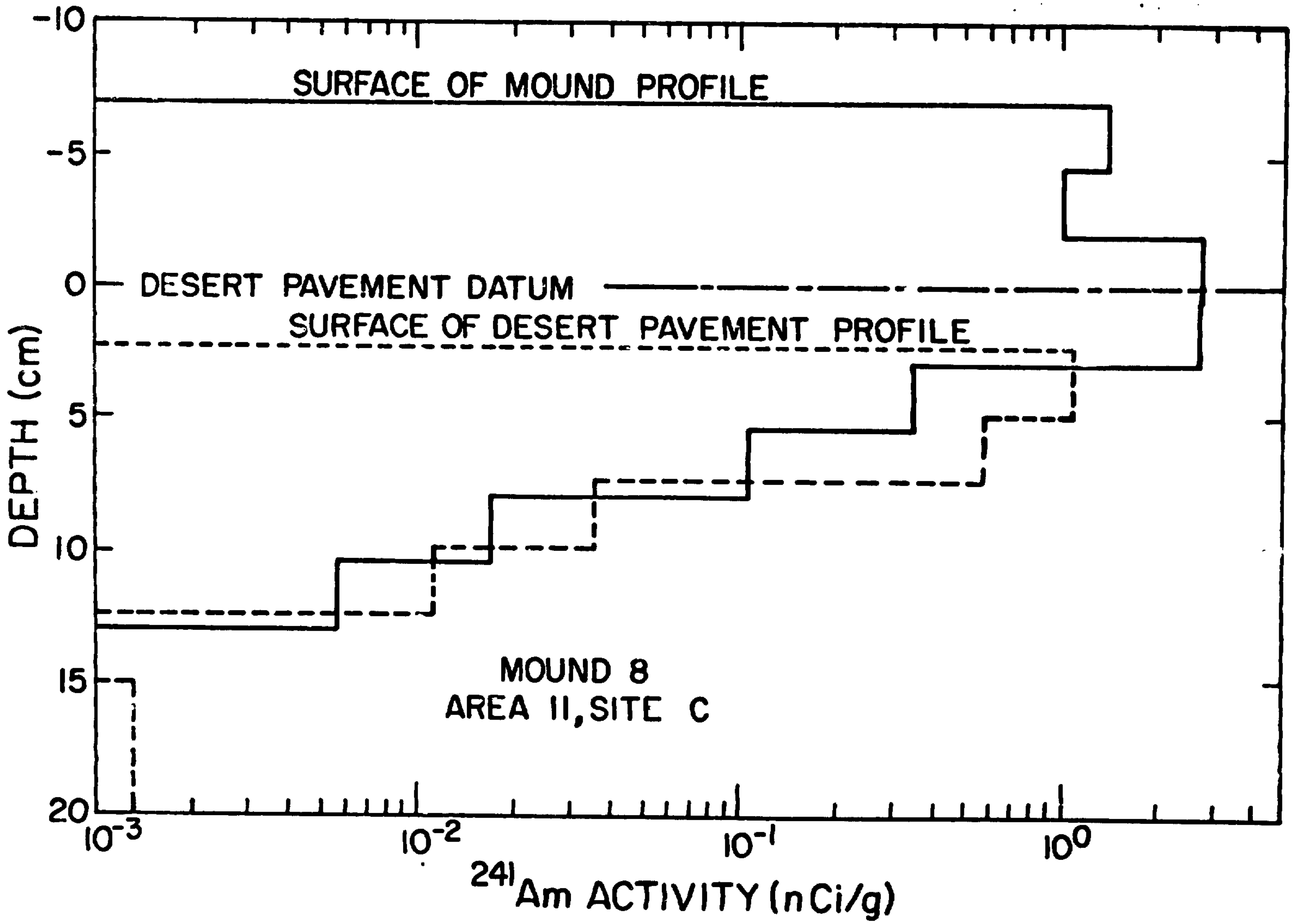


Fig. 8. Distribution of ^{241}Am in mound and desert pavement profiles. Vertical position of each profile is normalized to the desert pavement datum.

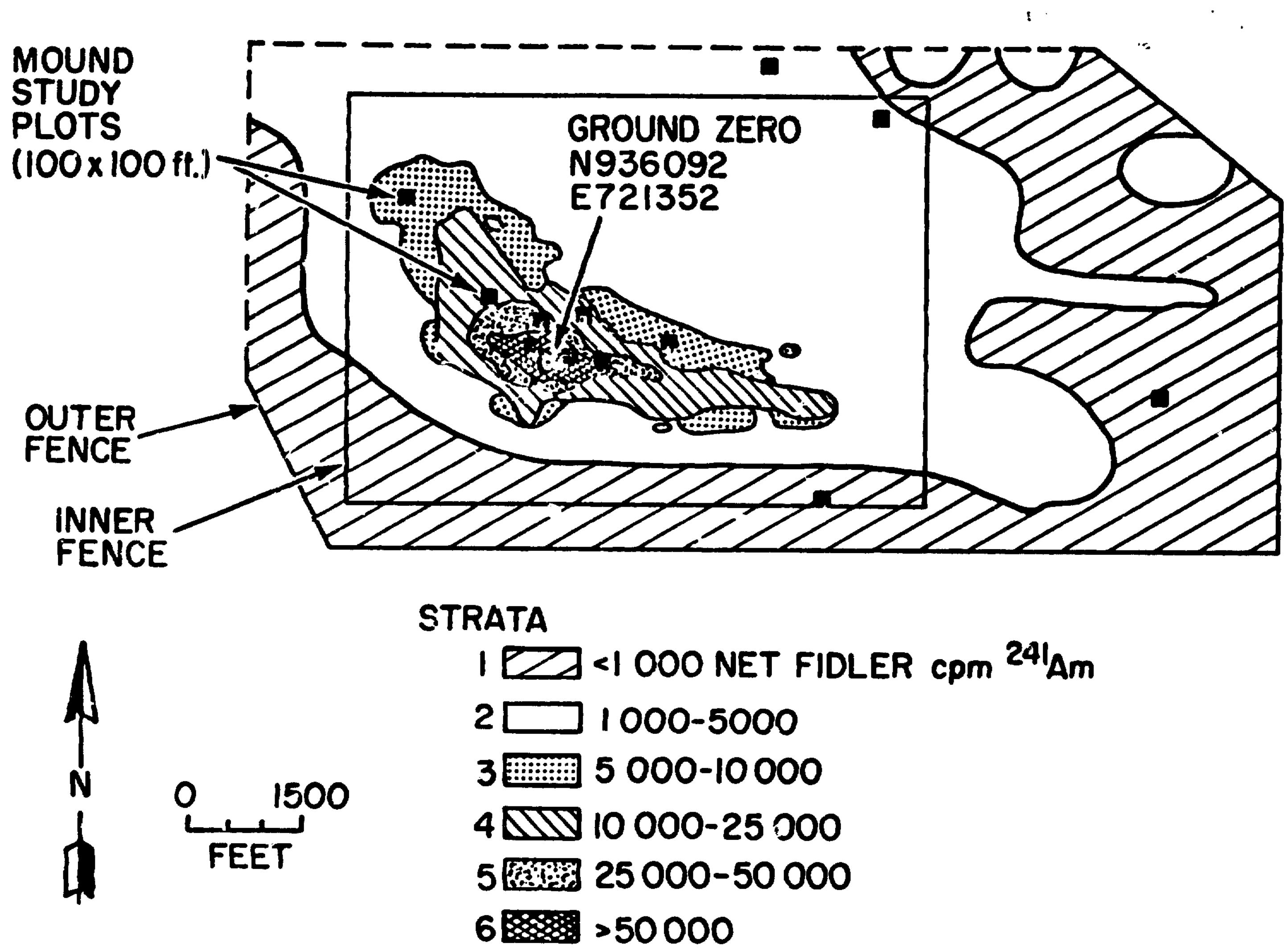


Fig. 9. Location of MS-2 plots relative to FIDLER activity strata at Project 57 in Area 13, NTS.

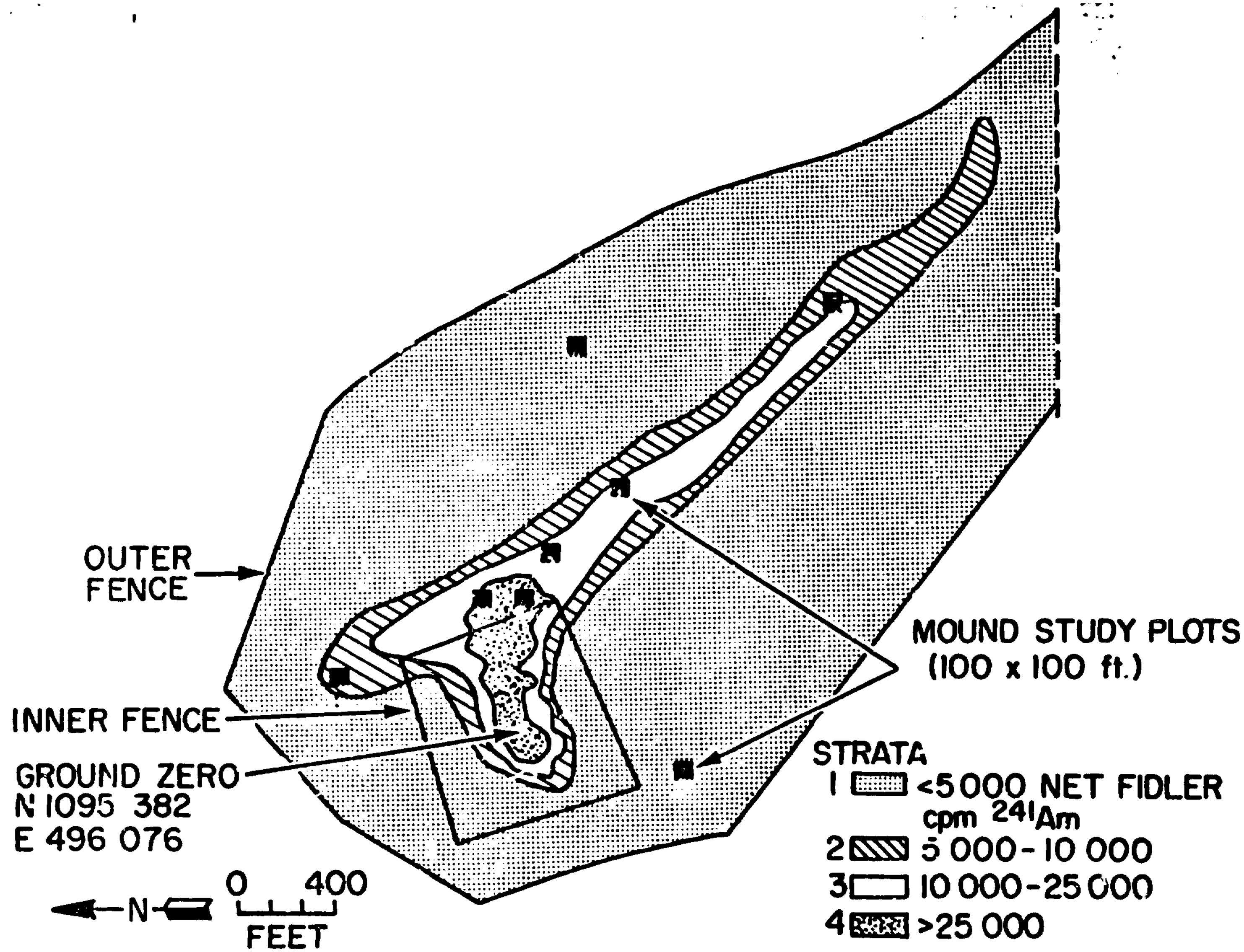


Fig. 10. Location of MS-2 plots relative to FIDLER activity strata at Clean Slate 3 in Area 52, TTR.

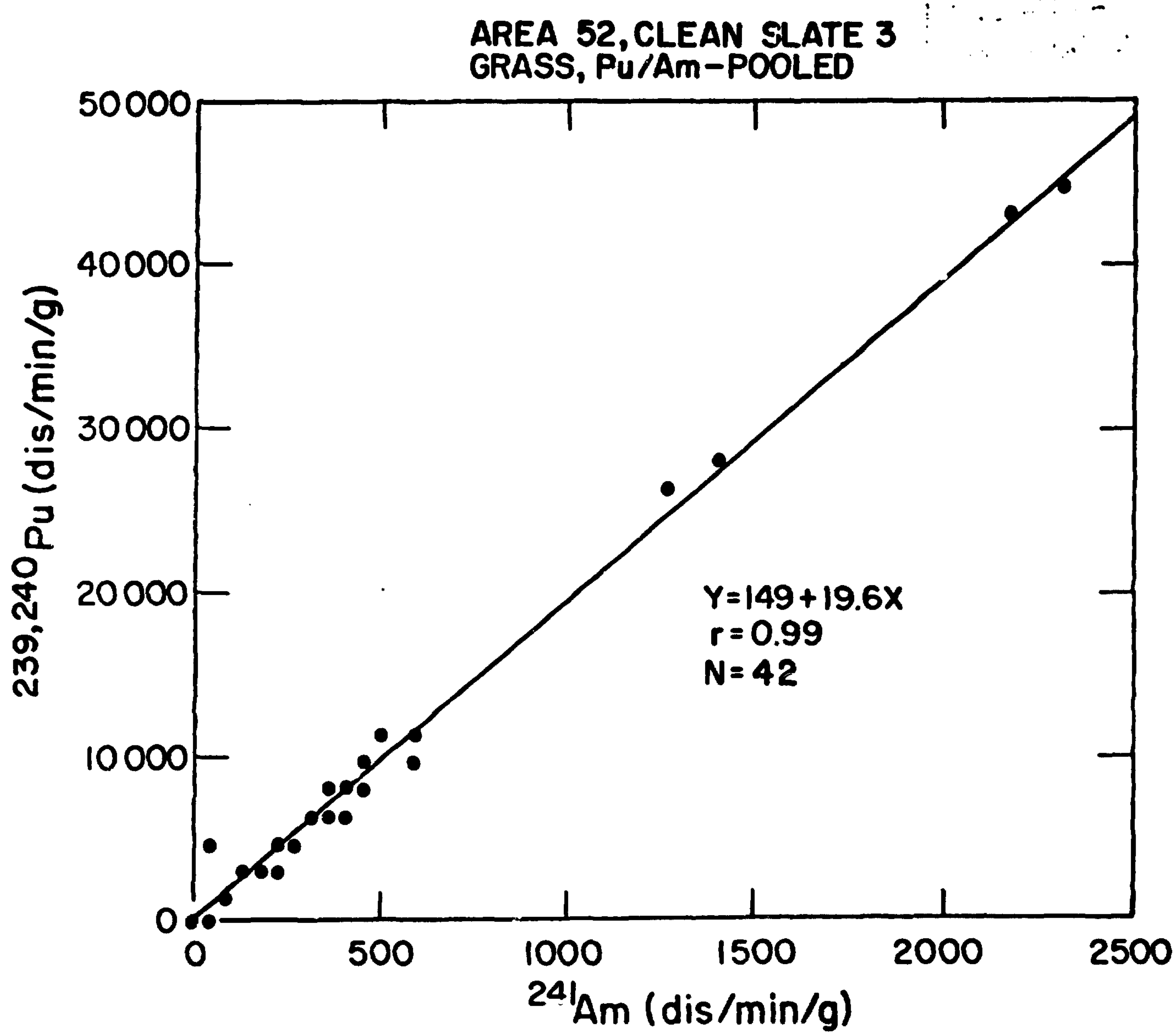


Fig. 11. Comparison of pooled $^{239,240}Pu$ and ^{241}Am in DP, MT, and MB samples from Grass mounds at Clean Slate 3 in Area 52, TTR.

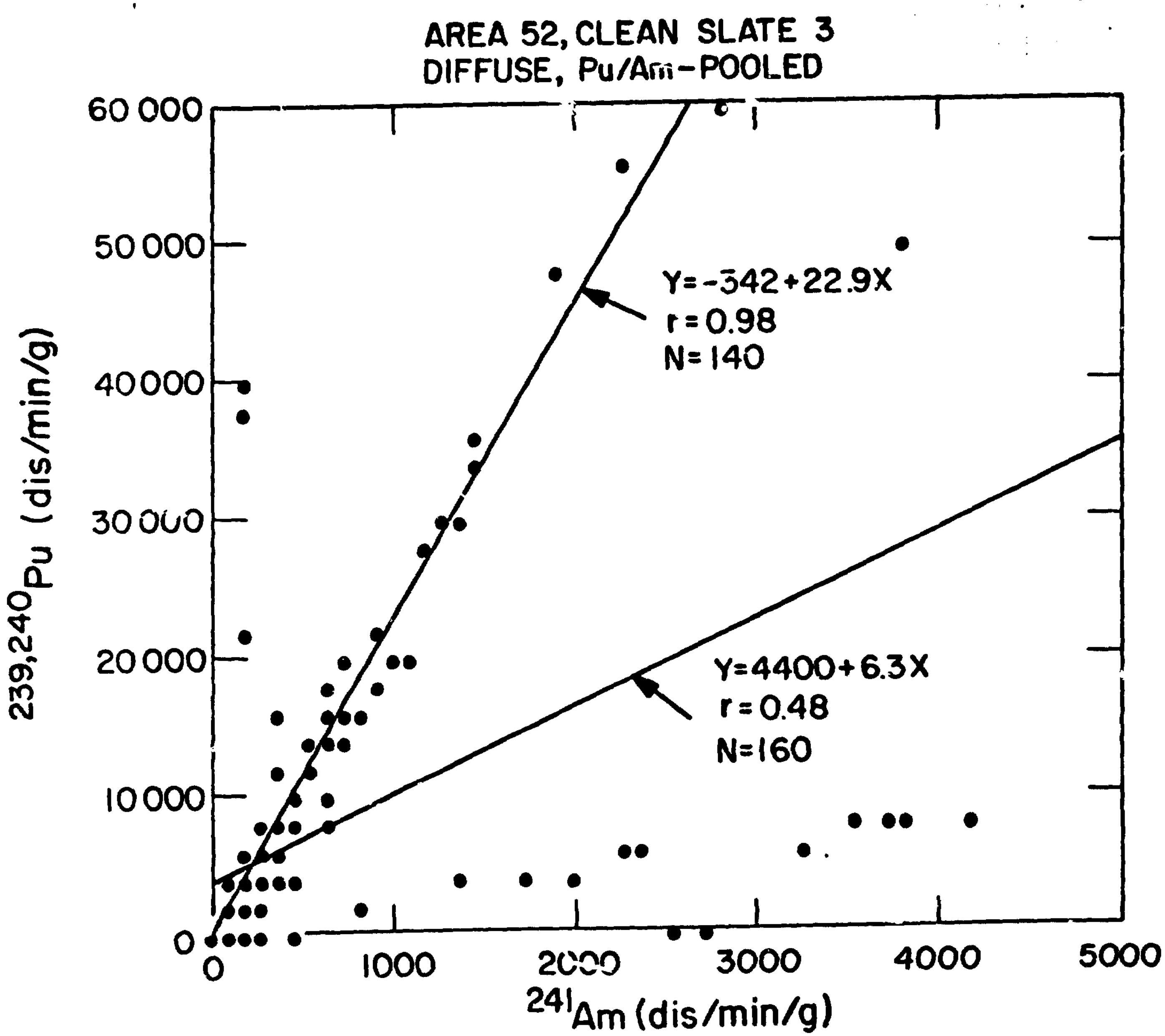
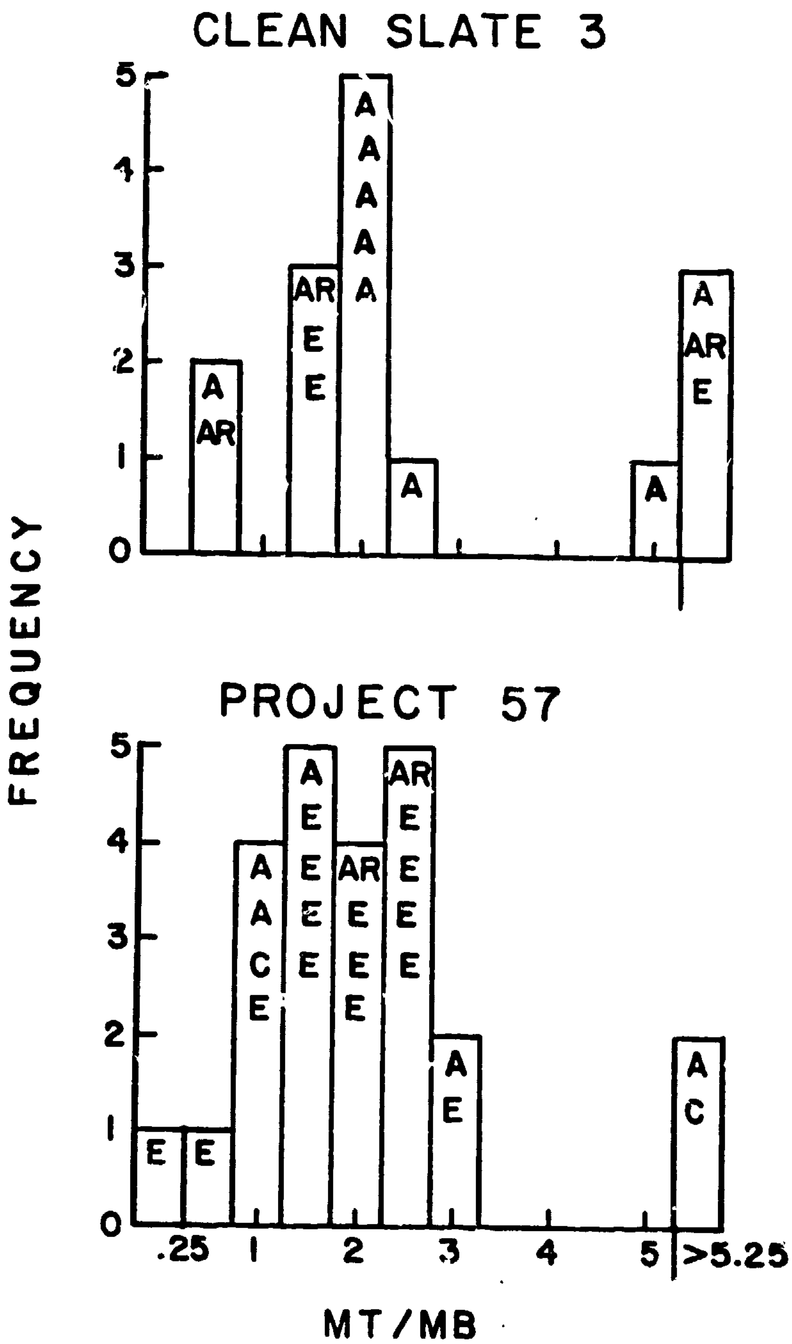


Fig. 12. Comparison of pooled ^{239,240}Pu and ^{241}Am in DP, MT, and MB samples from Diffuse mounds at Clean Slate 3 in Area 52, TTR.



A = *Atriplex confertifolia*
AR = *Artemisia spinescens*
E = *Eurotia lanata*
C = *Chrysothamnus visicidiflorus*

Fig. 13. Comparison of MT to MB ratios of ^{239,240}Pu to vegetation species of Shrub mounds at Clean Slate 3, Area 52, and Project 57, Area 13.

APPENDIX A

MOUND STUDY 1, DATA SUMMARY

The locations of mound/desert pavement profile pairs are shown in Fig. A-1 relative to Area 11, Site C ground zero (GZ). The 100-ft by 100-ft square plot was gridded into one hundred 10-ft by 10-ft squares, within which 10 desert pavement locations were randomly selected. Within a 10-ft radius of each desert pavement location, a mound was selected. From each selected location, a pair of soil profiles were collected to a depth of 25 cm in 2.5-cm increments, one from the desert pavement and one from the mound. Table A-1 lists the actual mound and desert pavement sampling locations relative to a reference stake.

Various measurements were made to determine the juxtaposition of the mound profile relative to the desert pavement profile. The only measurements included here are the elevations of each profile increment relative to the land surface datum. This information is listed in Table A-2, where the elevation (height) data indicate that the mound profile is positioned a number of centimeters above the desert pavement profile. FIDLER measurements were also taken 1 ft above each profile location before the profile samples were taken (Table A-2).

Americium-241 was estimated (30 min counts or until a ±10% or less counting error was obtained) on each profile increment using the 60 keV gamma emissions of ^{241}Am; these data are also shown in Table A-2 and positioned so that the projected land surface datum of the mound profile is aligned with the datum of the desert pavement profile. Where ^{241}Am values are not listed, the level of ^{241}Am in the sample was below the detection limit of the counting system.

Table A-1
Mound Study - Profile Locations
at Site C in Area 11, NTS

Mound Number	Location Relative to Reference Stake			
	Mound Profile		Desert Pavement Profile	
	N(ft)	E(ft)	N(ft)	E(ft)
1	392	160	384	164
2	345	111	340	106
3	399	175	402	171
4	350	200	354	208
5	367	135	367	143
6	316	137	308	135
7	375	200	369	198
8	340	142	334	140
9	331	120	332	113
10	325	102	320	105
Ground Zero Location:	N810 908.57		E707 411.94	
Reference Stake Location:	N810 600		E707 200	

Table A-2

Americium-241 in Mound and Desert Pavement (DP) Profiles

Height rel to DP Datum (cm)		^{241}Am (nCi/g)	
Mound	DP	Mound	DP
Mound No. 1			
13.4		0.43	
10.9		0.013	
8.4		0.12	
5.9		0.035	
3.4		0.025	
0.9		0.028	
-1.6	-1.2	0.0074	0.56
-4.1	-3.7	0.0030	0.027
-6.6	-6.2		0.0066
-9.1	-8.7		0.0015
	-11.2		--
	-13.7		--
	-16.2		--
	-18.7		--
	-21.2		--
	-23.7		--
FIDLER (c/m)		96000	86000
Mound No. 2			
8.8		1.8	
0.3		1.9	
3.8		0.60	
1.3		0.015	
-1.2	-1.2	0.0080	1.9
-3.7	-3.7	0.0035	0.056
-6.	-6.2	--	0.0083
-8.7	-8.7	0.017	0.052
-11.2	-11.2	0.0071	--
-13.7	-13.7		0.0032
	-16.2		0.016
	-18.7		--
	-21.2		--
	-23.7		--
FIDLER (c/m)		290000	190000
Mound No. 3			
11.3		1.8	
8.8		1.3	
6.3		0.30	
3.8		0.075	
1.3	1.5	0.025	0.51
-1.2	-1.0	0.013	0.047
-3.7	-3.5	0.051	0.0058
-6.2	-6.0	0.050	0.023
-8.7	-8.5	0.075	0.0024
-11.2	-11.0	0.042	--
	-13.5		0.0048
	-16.0		--
	-18.5		--
	-21.0		--
FIDLER (c/m)		200000	86000
Mound No. 4			
7.9		0.93	
5.4		0.69	
2.9		0.14	
0.4	0.3	0.10	0.32
-2.1	-2.2	0.025	0.054
-4.6	-4.7	0.015	0.0094
-7.1	-7.2	0.030	--
-9.6	-9.7	0.015	--
-12.1	-12.2	0.0063	--
-14.6	-14.7	--	--
	-17.2	--	--
	-19.7		--
	-22.2		--
FIDLER (c/m)		140000	94000

Table A-2 (cont)

Height rel to DP Datum (cm)		^{241}Am (nCi/g)		Height rel to DP Datum (cm)		^{241}Am (nCi/g)	
Mound	DP	Mound	DP	Mound	DP	Mound	DP
Mound No. 5				Mound No. 6			
12.5		0.35		10.7		1.6	
10.0		0.11		8.2		3.4	
7.5		0.0089		5.7		0.30	
5.0		0.0048		3.2		0.20	
2.5		0.0025		-0.7	1.2	0.0059	
-0.0		0.0013		-1.8	-1.3	--	[illegible]
-2.5		--		-4.3	-3.8	--	[illegible]
-5.0		--		-6.8	-6.3	0.0026	[illegible]
-7.5		0.0020		-9.3	08.8	--	0.0081
-10.0	-9.8	--	0.50	-11.8	-11.3	--	--
	-12.3		0.014		-13.8		--
	-14.8		0.017		-16.3		--
	-17.3		0.0075		-18.8		--
	-19.8		0.0067		-21.3		--
	-22.3		--				
	-24.8		--				
	-27.3		0.0013				
	-29.8		0.0021				
	-32.3		--				
FIDLER (c/m)		85000	84000	FIDLER (c/m)		180000	300000
Mound No. 7				Mound No. 8			
8.5		7.1		7.0		1.4	
6.0		1.1		4.5		1.0	
3.5		0.081		2.0		2.7	
1.0		0.027		-0.5		2.7	
-1.5		0.0085		-3.0	-2.4	0.35	1.1
-4.0	-4.9	--	1.1	-5.5	-4.9	0.11	0.57
-6.5	-7.4	--	0.0074	-8.0	-7.4	0.017	0.035
-9.0	-9.9	--	--	-10.5	-9.9	0.0056	0.011
-11.5	-12.4	--	0.0037	-13.0	-12.4	--	--
-14.0	-14.9	--	--	-15.5	-14.9	--	0.0013
	-17.4		--		-17.4		0.0013
	-19.9		--		-19.9		--
	-22.4		--		-22.4		--
	-24.9		--		-24.9		--
	-27.4		--				
FIDLER (c/m)		590000	96000	FIDLER (c/m)		96000	86000

Table A-2 (cont)

Height rel to DP Datum (cm)		^{241}Am (nCi/g)		Height rel to DP Datum (cm)		^{241}Am (nCi/g)	
Mound	DP	Mound	DP	Mound	DP	Mound	DP
Mound No. 9				Mound No. 10			
9.7		7.9		7.3		4.0	
7.2		8.5		4.8	3.6	4.1	5.0
4.7		0.28		2.3	1.1	0.62	1.7
2.2		0.034		-0.2	-1.4	0.054	0.025
-0.3	0.9	0.038	0.90	-2.7	-3.9	0.0057	0.0023
-2.8	-1.6	--	0.016	-5.2	-6.4	--	0.0037
-5.3	-4.1	0.0058	0.0090	-7.7	-8.9	--	--
-7.8	-6.6	--	0.0006	-10.2	-11.4	--	--
-10.3	-9.9	--	0.0042	-12.7	-13.9	--	--
-12.8	-11.6	0.0046	--	-15.2	-16.4	--	--
	-14.1		--		-18.9		--
	-16.6		--				
	-19.1		--				
	-21.6		--				
FIDLER (c/m)		300000	150000	FIDLER (c/m)		400000	200000

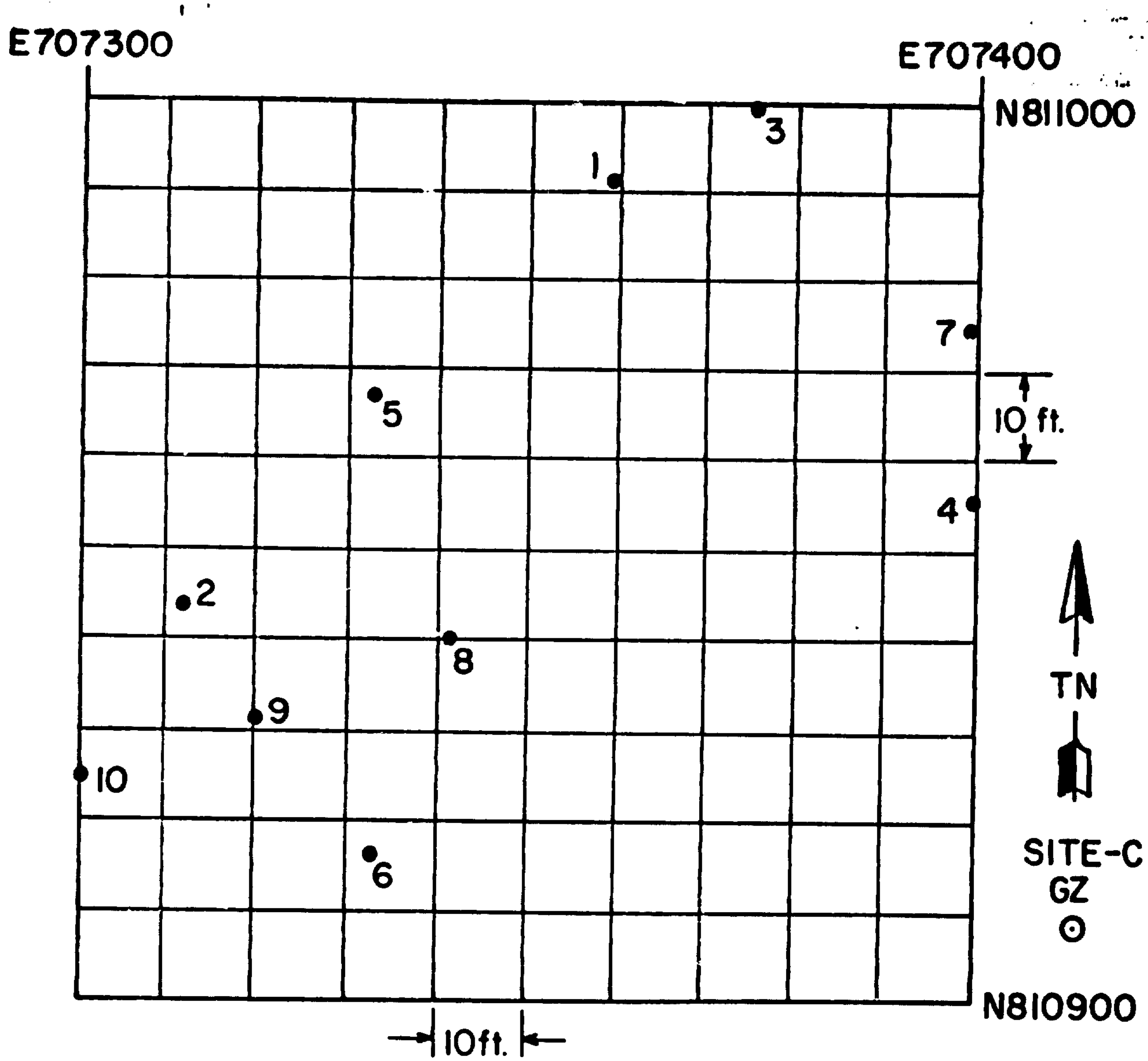


Fig. A-1. Plan view of Area 11, Site C Mound Study 1, randomly selected mound sampling locations.

APPENDIX B

MOUND STUDY 2, DATA SUMMARY

Additional data relative to the sampling plot locations and distributions of $^{239,240}Pu$ and Total-U for Mound Study 2 are given. Table B-1 summarizes the sampling plot locations referenced to Nevada Grid Coordinates for Clean Slate 3 in Area 52, and Project 57 in Area 13. The location of the northwest corner of each 100-ft by 100-ft square plot is given as the reference location.

Figure B-1 shows how each 100-ft by 100-ft square plot was partitioned. One of the four quadrants was randomly selected for sampling; that quadrant was divided into five quadrates for ease of counting the various mound types. Figure B-2 is an idealized sketch of the distribution of one mound type in the 50-ft by 50-ft square quadrant. The two blackened mounds represent those that were randomly chosen for sampling.

Many measurements were made of each mound, some of which are shown in Fig. B-3. SPXR represents the location of the desert pavement sample collected with each mound. The measurements HN, HS, and HMP represent elevations relative to the desert pavement datum. The W measurements represent total width at the point shown, and the T values represent the distance from the center line, HN to HS, to the edge of the mound. The rest of the measurements are self-explanatory. The actual measurements are not presented in this report but are available in the NAEG data base for Mound Study 2.

Diffuse mounds were sampled differently from all other mound types. Each diffuse mound was sketched on coordinate paper; each square was numbered and up to four sampling points were selected by selection of four random numbers. Figure B-4 shows a diffuse mound, as sketched, and the locations of the four sampling points. The circles adjacent to each chosen sampling point represent the location of the desert pavement sample collected corresponding to each mound sample.

Figures B-5 through B-9 summarize the $^{239,240}Pu$ and Total-U data used to help compare mound top (MT), mound bottom (MB), and desert pavement (DP) samples for the various mound types at Clean Slate 3 and Project 57. Each plot represents the pooled data for the respective variables. In each figure are two plots, one representing a linear comparison of the two variables and the other a log-log comparison. Because of the wide range of concentrations observed, a linear plot tends to mask many of the lower activities appearing to more heavily weight the larger values. Therefore, the log-log plot is presented to show the relative location of the lower activity values. The lines and repective equations of each graph were determined by simple least squares fit of the data (for the log-log plots the log of each value was used). Correlation coefficients are given with each fit.

The data is presented in this manner to show 1) that the observations tend to cluster along a straight line particularly in the log-log presentation, 2) that there is considerable variability in calculated ratios (represented by points far from the linear least squares fit), and 3) that the points do not tend to cluster around the straight line expected if MT = MB and MT = DP. The plot of MB vs DP (Fig. B-8) does show that the data cluster around MB = DP.

For purposes of better visualizing the distributions of the various calculated ratios, with respect to the ratio of 1, the data are presented in a series of histograms (Fig. B-10 through B-17). The ratio of MT to MB is presented in histogram form based on the concentration of $^{239,240}Pu$ in MT divided by that in MB. The frequency histogram shows the actual calculated ratio of MT to MB on the left side of 1 for ratios of 0 to 1, and the inverse of the ratio on the right side of 1 for ratios of 1 to infinity in order to better resolve the ratios between 0 and 1. Also shown are the arithmetic means ($\bar{X}$), standard deviation (s), median (MED), and number of values (N) in the distribution of ratios. The arithmetic mean noted with each histogram is the mean of the ratios and not the ratio of the means as was presented in the text of the paper. The second, third, and fourth frequency histograms are for ratios calculated on an area basis; the total amount of $^{239,240}Pu$ is calculated based on the amount of land surface included in each sample type. The last frequency histogram of each figure summarizes the ratio of Total-U in the MT and MB based on concentration in each sample type.

Examination of the ratio distributions suggests a number of similarities, for example, all the mound types except Animal appear to have a similar distribution of MT to MB ratios calculated on the basis of concentration. Figure B-17 shows all of the various ratios pooled except for ratios from the Animal mounds (Fig. B-13). Means and standard deviations for the pooled data are calculated and weighted from the individual means and standard deviations.

Table B-1

Mound Study 2 Plot Locations[a]

Plot ID	Nevada Grid Coordinates N	Nevada Grid Coordinates E	Relative to GZ Dist (ft)	Relative to GZ AZI (°)
Clean Slate 3, Area 52				
GZ	1 095 381.63	496 075.91		
1A	1 094 682	495 876	728	196
1B	1 095 282	497 676	1603	93.6
2A	1 094 082	497 776	2140	127
2B	1 096 182	496 276	825	14
3A	1 095 282	496 776	700	98
3B	1 094 982	497 076	1077	111
4A	1 095 582	496 576	539	68.2
4B	1 095 382	496 576	500	90
Project 57, Area 13				
GZ	936 092	721 352		
1A	936 200	723 100	1962	117
1B	936 300	725 300	3953	87
2A	938 300	722 700	2587	31.4
2B	937 800	723 600	2823	52.8
3A	937 200	720 300	1528	224
3B	936 300	722 100	776	74.5
4A	936 500	721 500	434	35.4
4B	936 600	720 800	750	317
5A	936 500	721 200	435	290
5B	936 200	721 700	364	72.8
6A	936 200	721 400	118	24
6B	936 300	721 100	327	320

[a]Location of NW corner of plot.

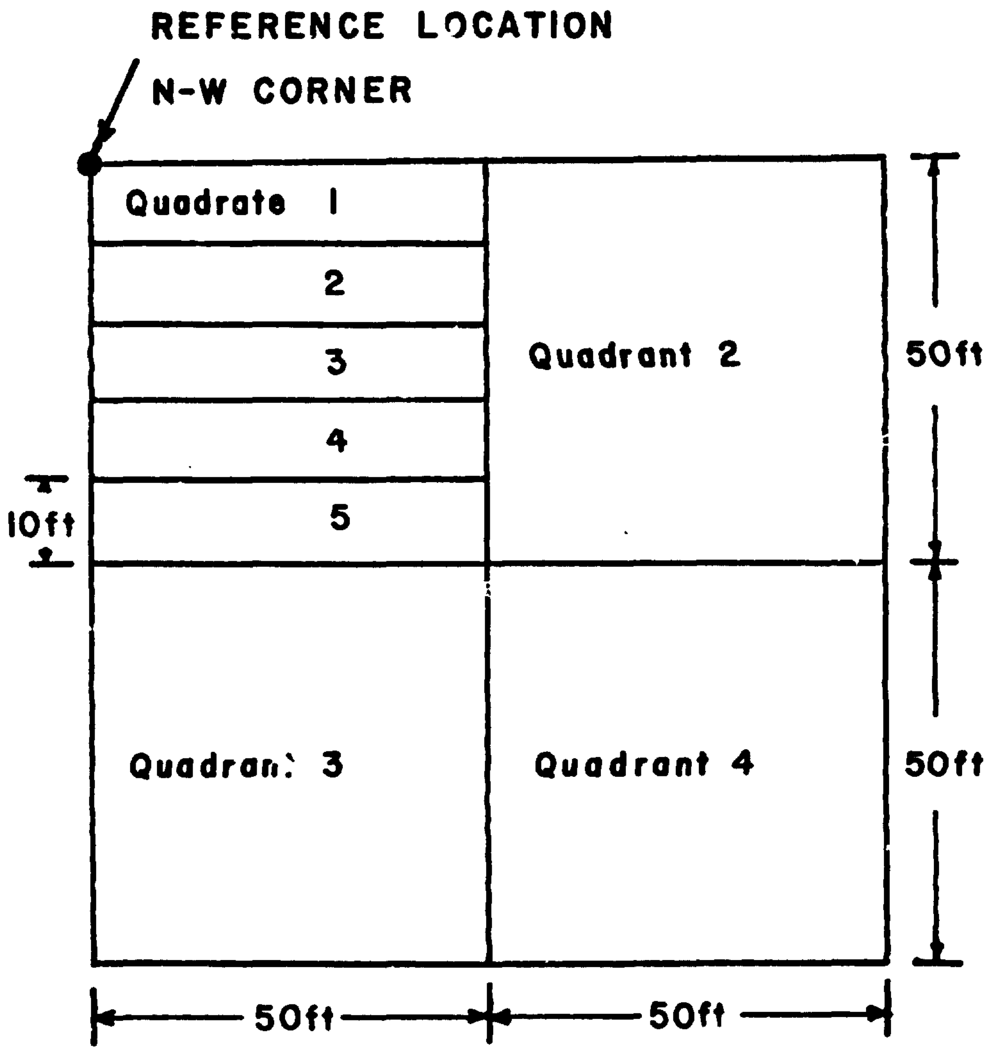


Fig. B-1. Mound Study 2 plot confiauration.

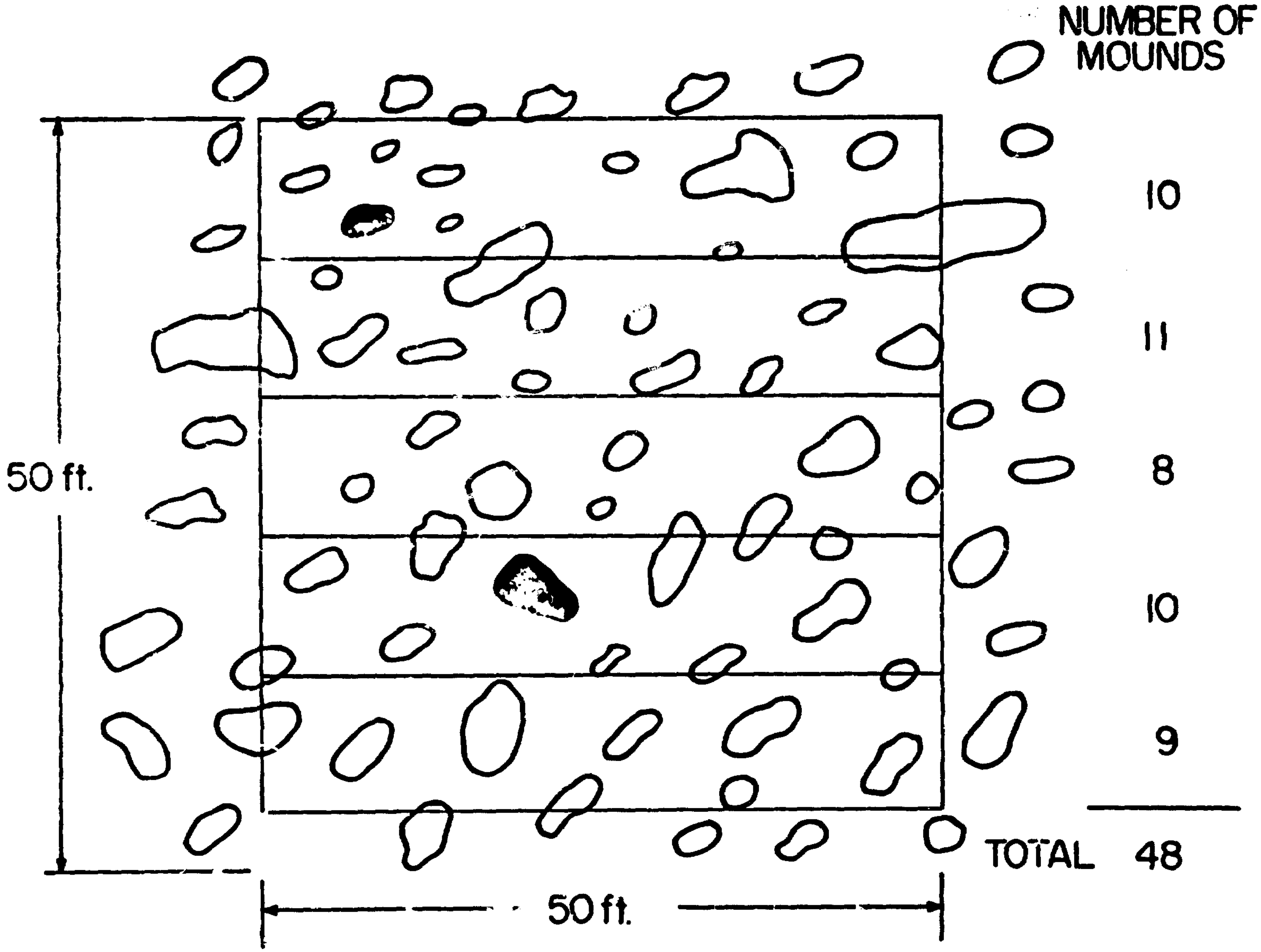


Fig. B-2. Hypothetical mound distribution in 50 ft square quadrate.

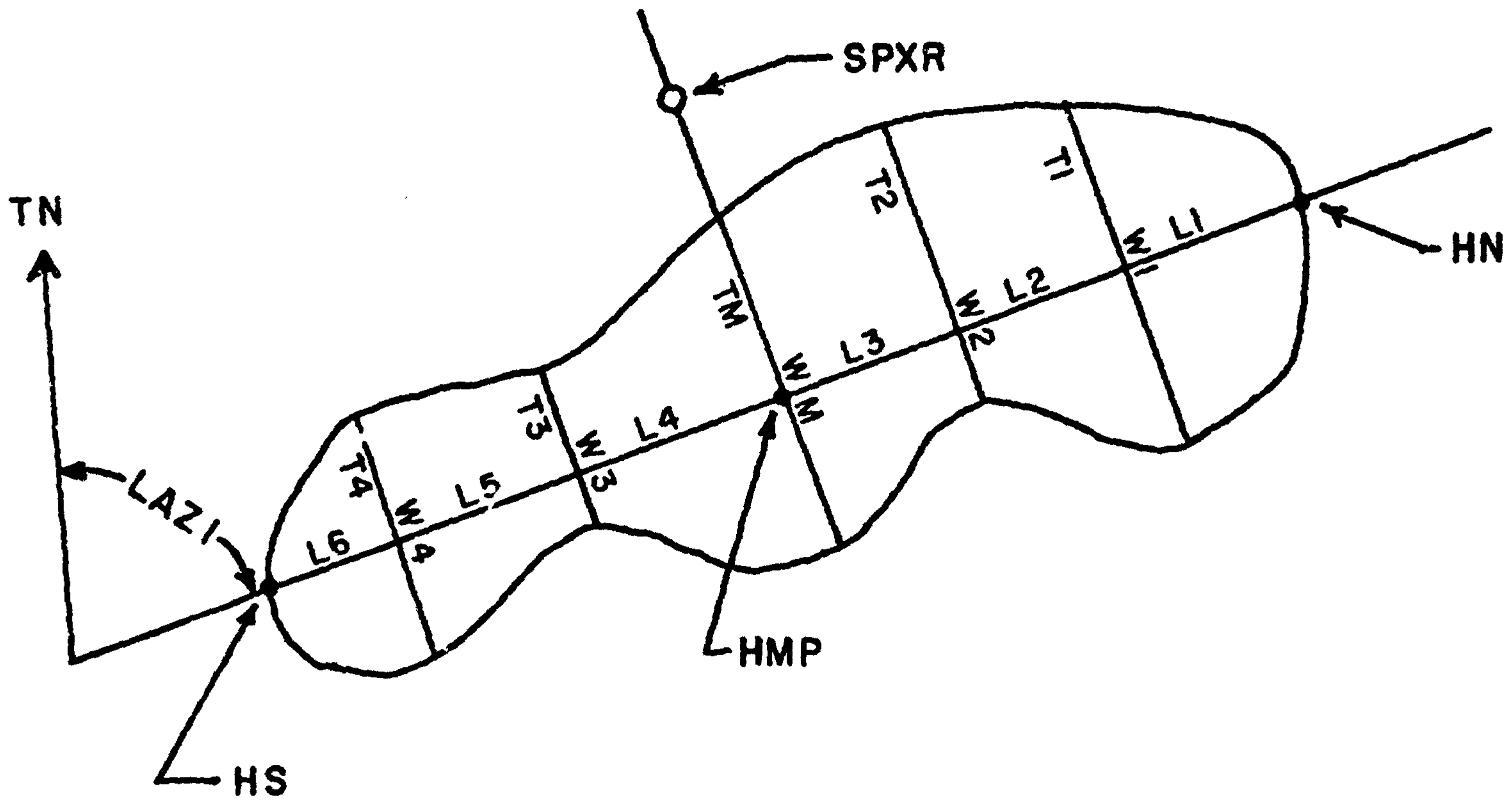


Fig. B-3. Typical measurements taken of each mound prior to sampling.

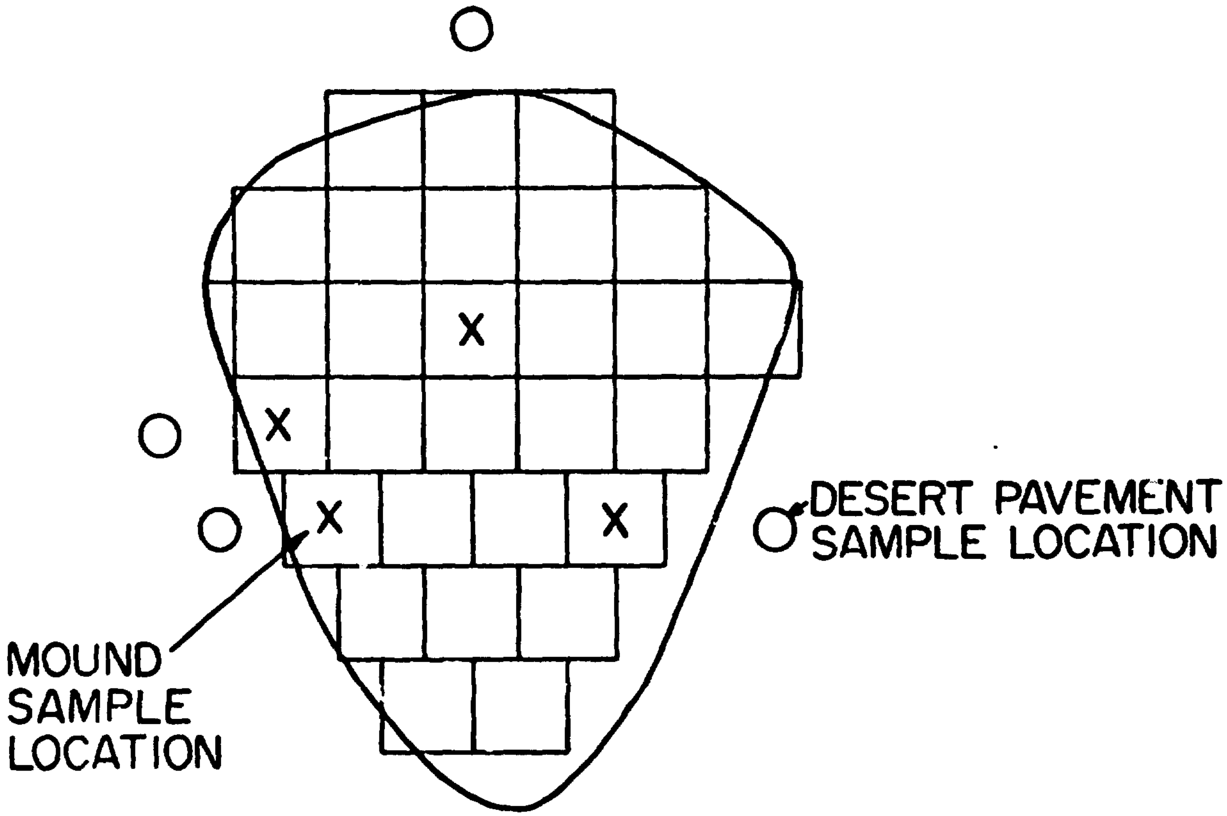


Fig. B-4. Diffuse mound showing location of randomly selected sampling points.

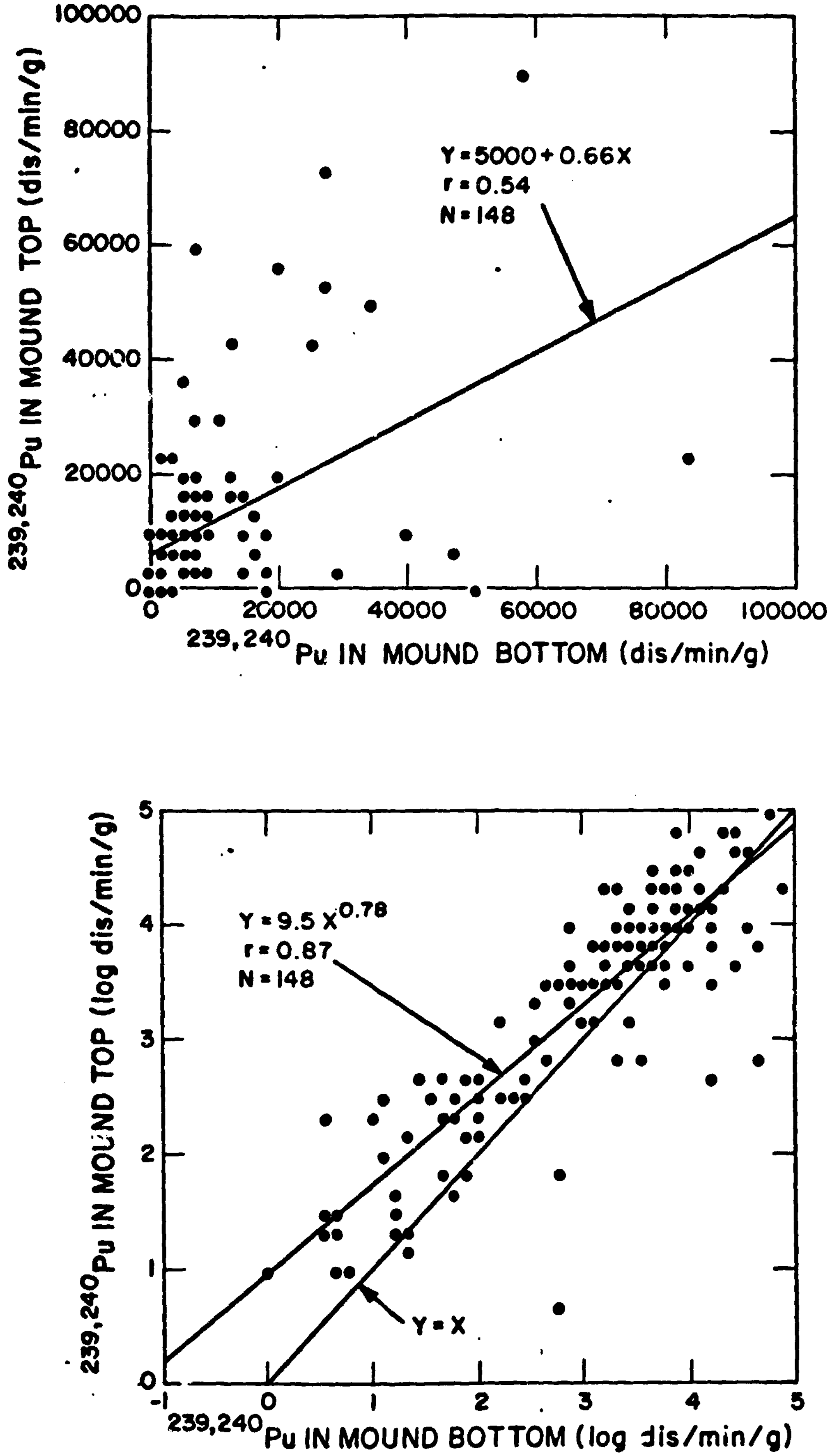


ILLUSTRATION
B-5A

Fig. B-5. Distribution of pooled ^{239,240}Pu in mound top and mound bottom based on concentration; all mound types except Animal

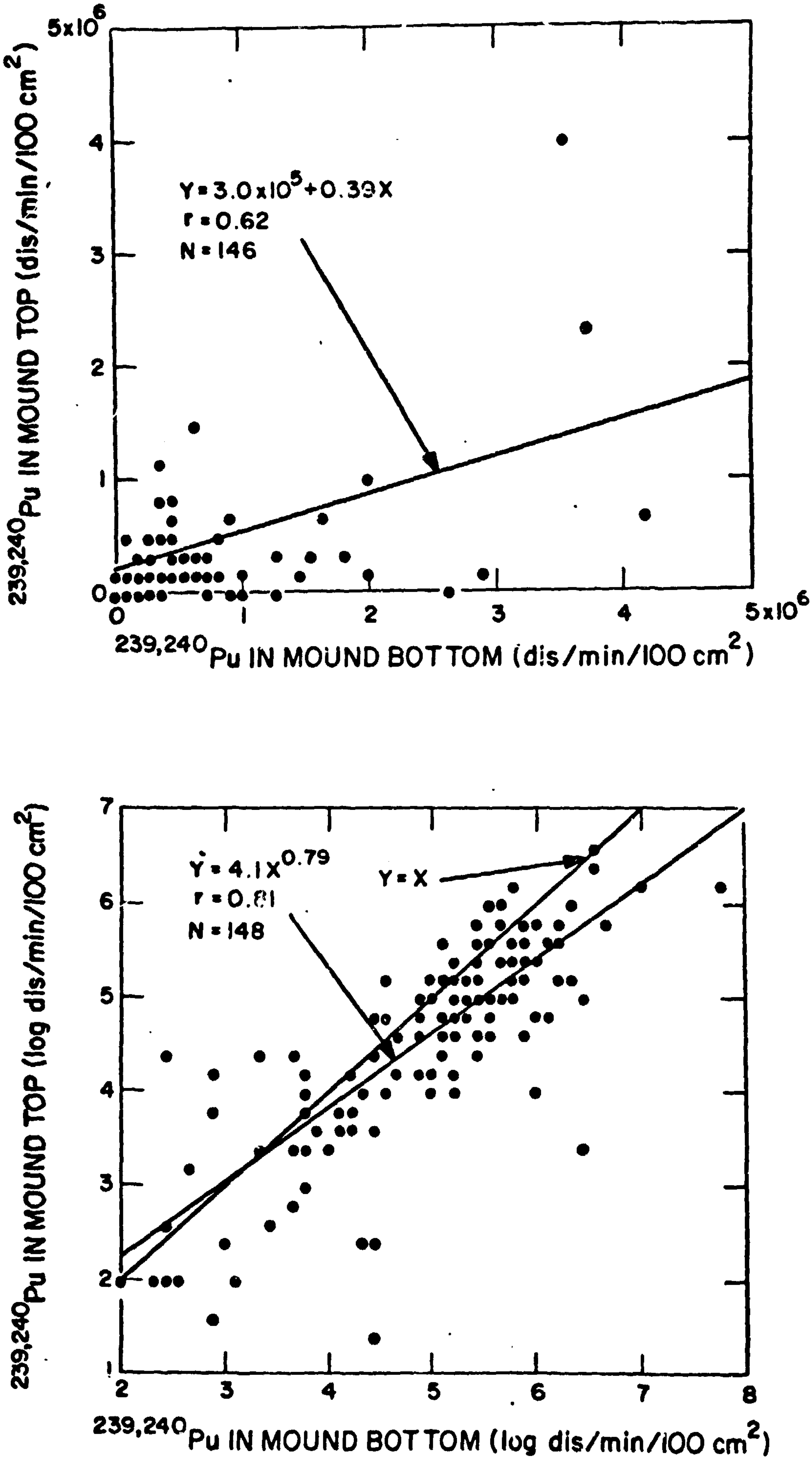
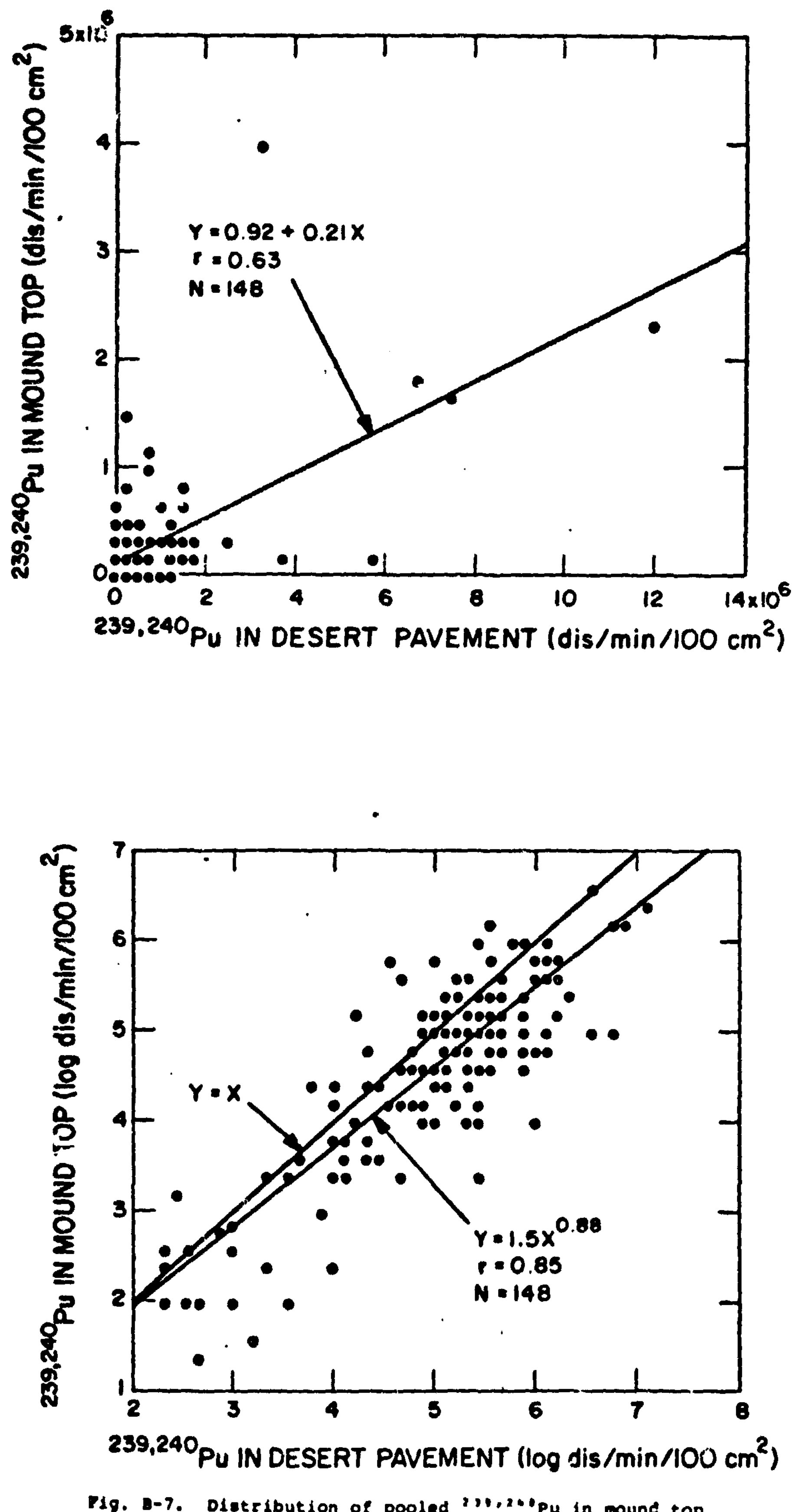
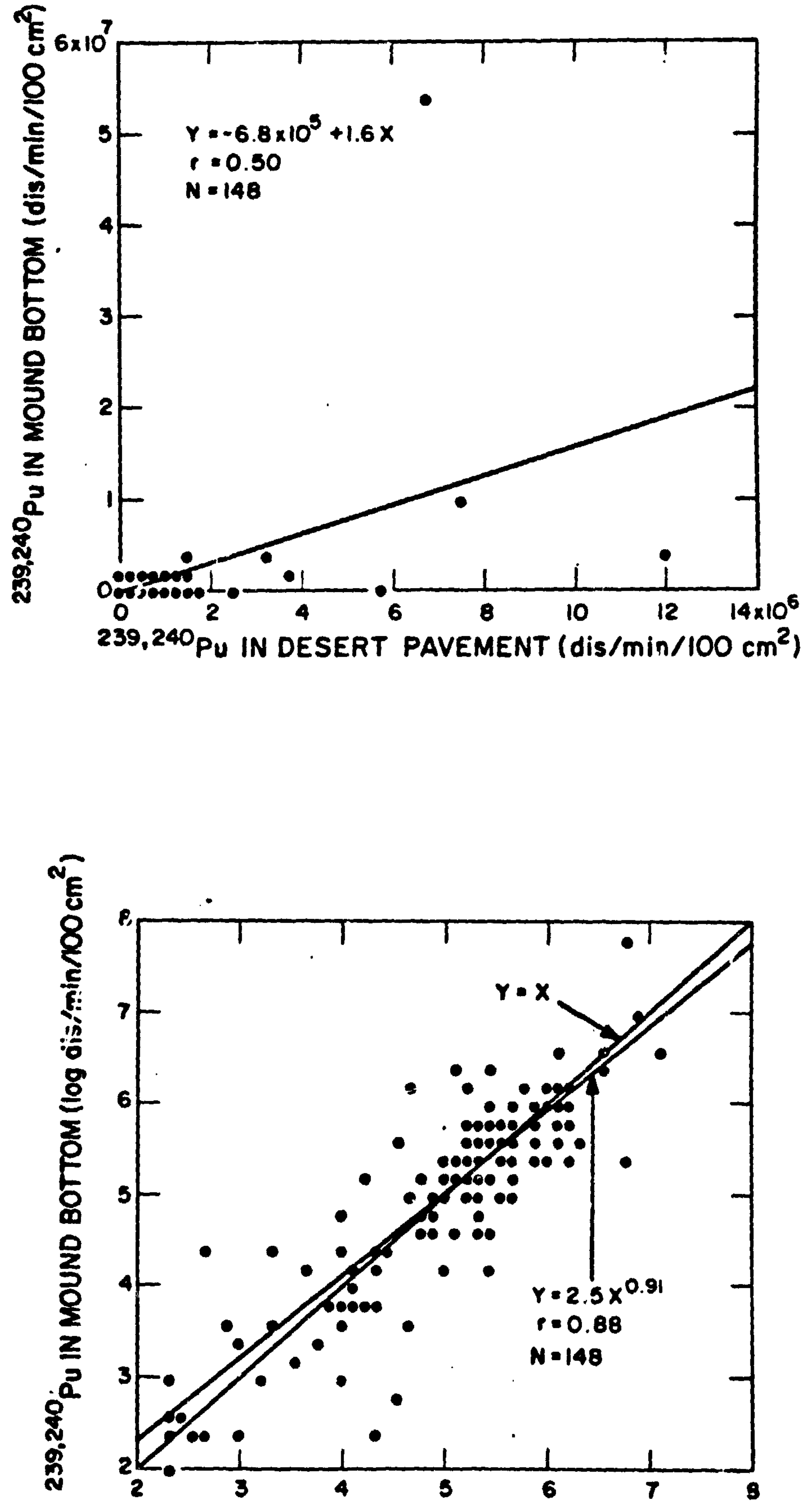


Fig. B-6. Distribution of pooled ^{239,240}Pu in mound top and mound bottom based on area; all mound types except Animal.



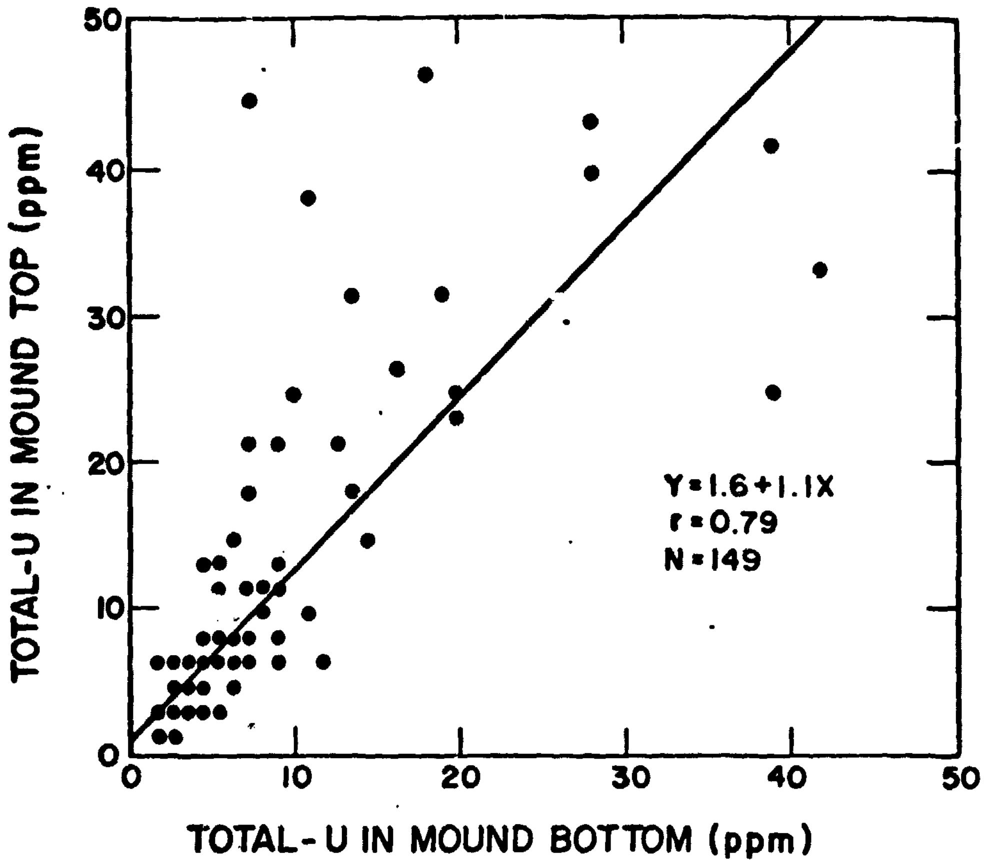
ILLUST B-7

Fig. B-7. Distribution of pooled $^{239,240}Pu$ in mound top and desert pavement based on area; all mound types except Animal.



ILLUSTR B-8 A

Fig. B-8. Distribution of pooled $^{239,240}Pu$ in mound bottom and desert pavement based on area; all mound types except Animal.



(B-9 A

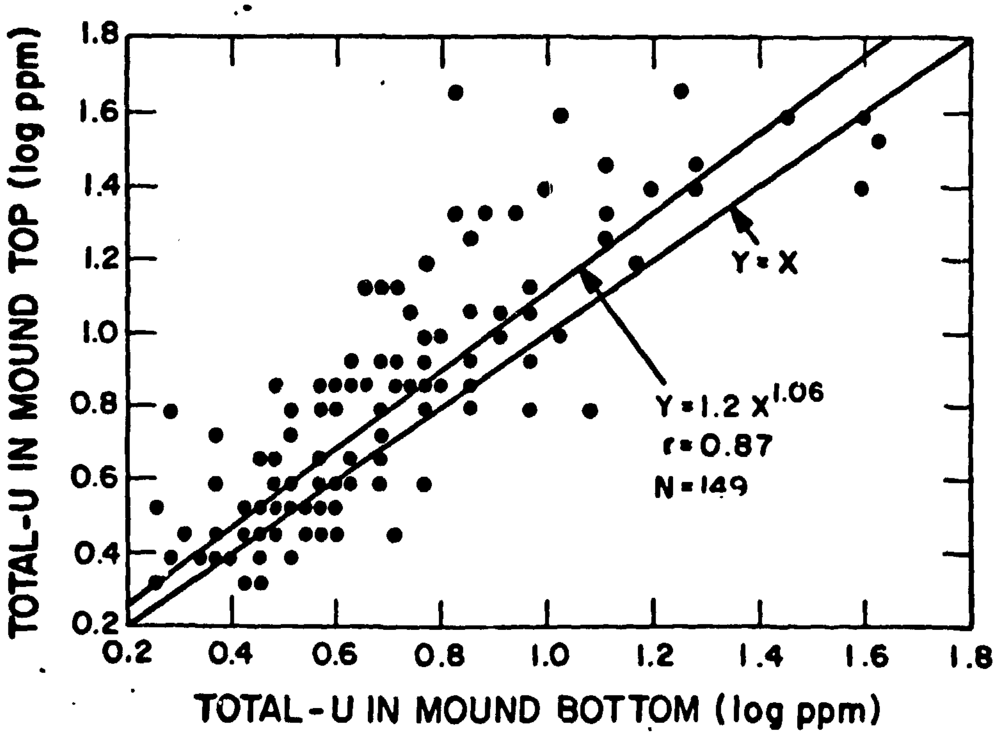


Fig. B-9. Distribution of pooled Total-U in mound top and mound bottom based on concentration; all mound types except Animal.

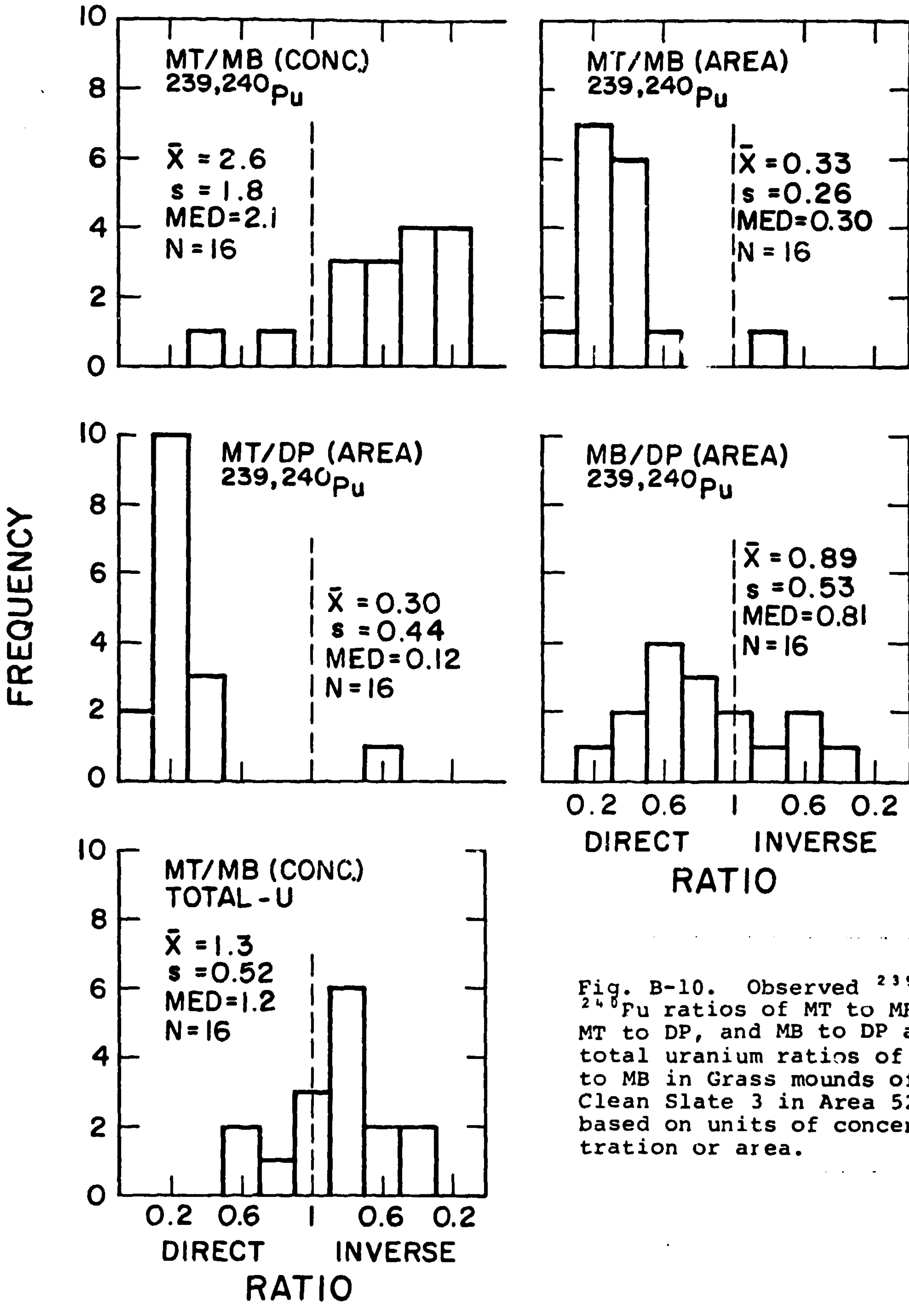


Fig. B-10. Observed $^{239,240}Pu$ ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Grass mounds of Clean Slate 3 in Area 52, based on units of concentration or area.

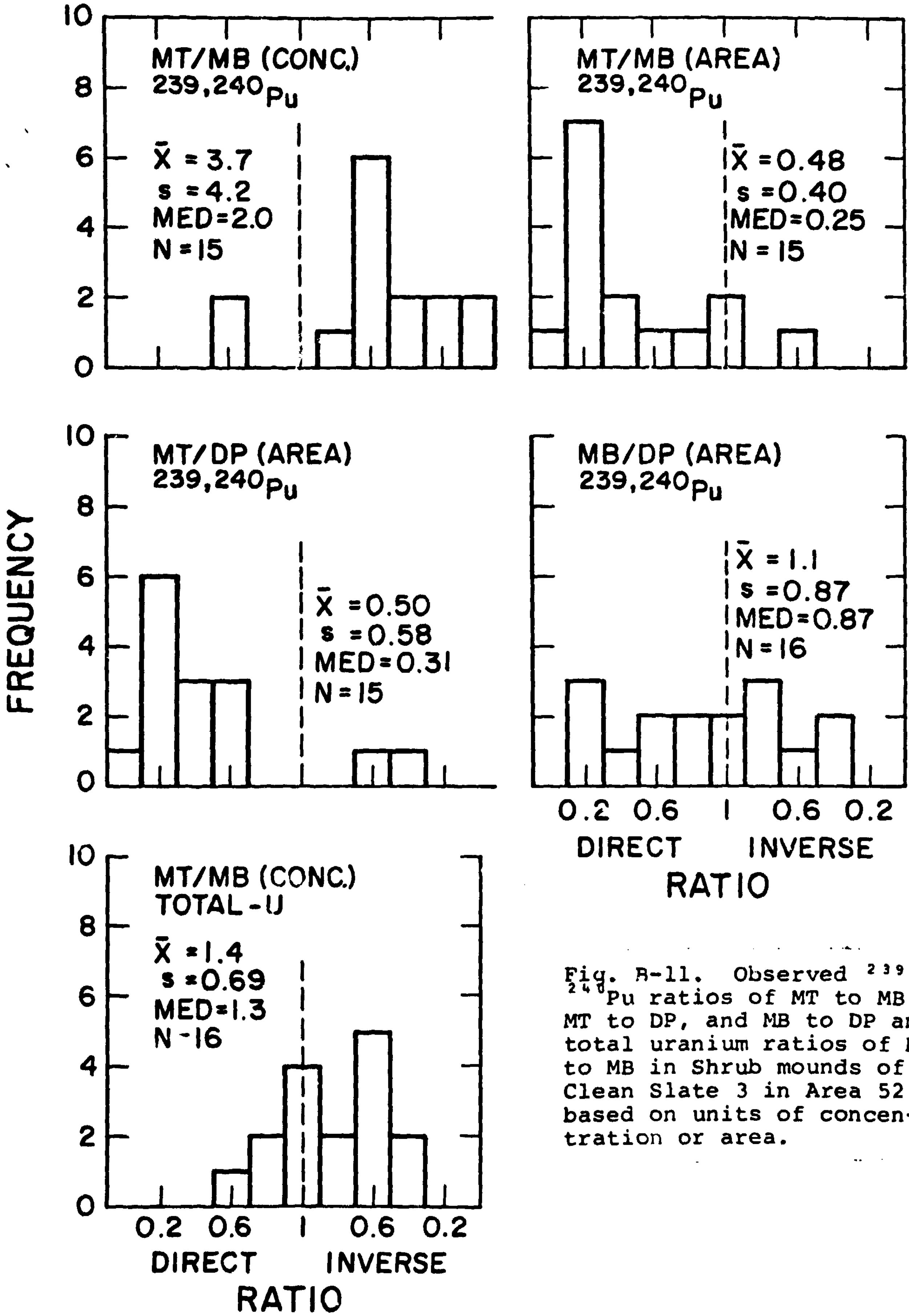


Fig. B-11. Observed $^{239,240}Pu$ ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Shrub mounds of Clean Slate 3 in Area 52, based on units of concentration or area.

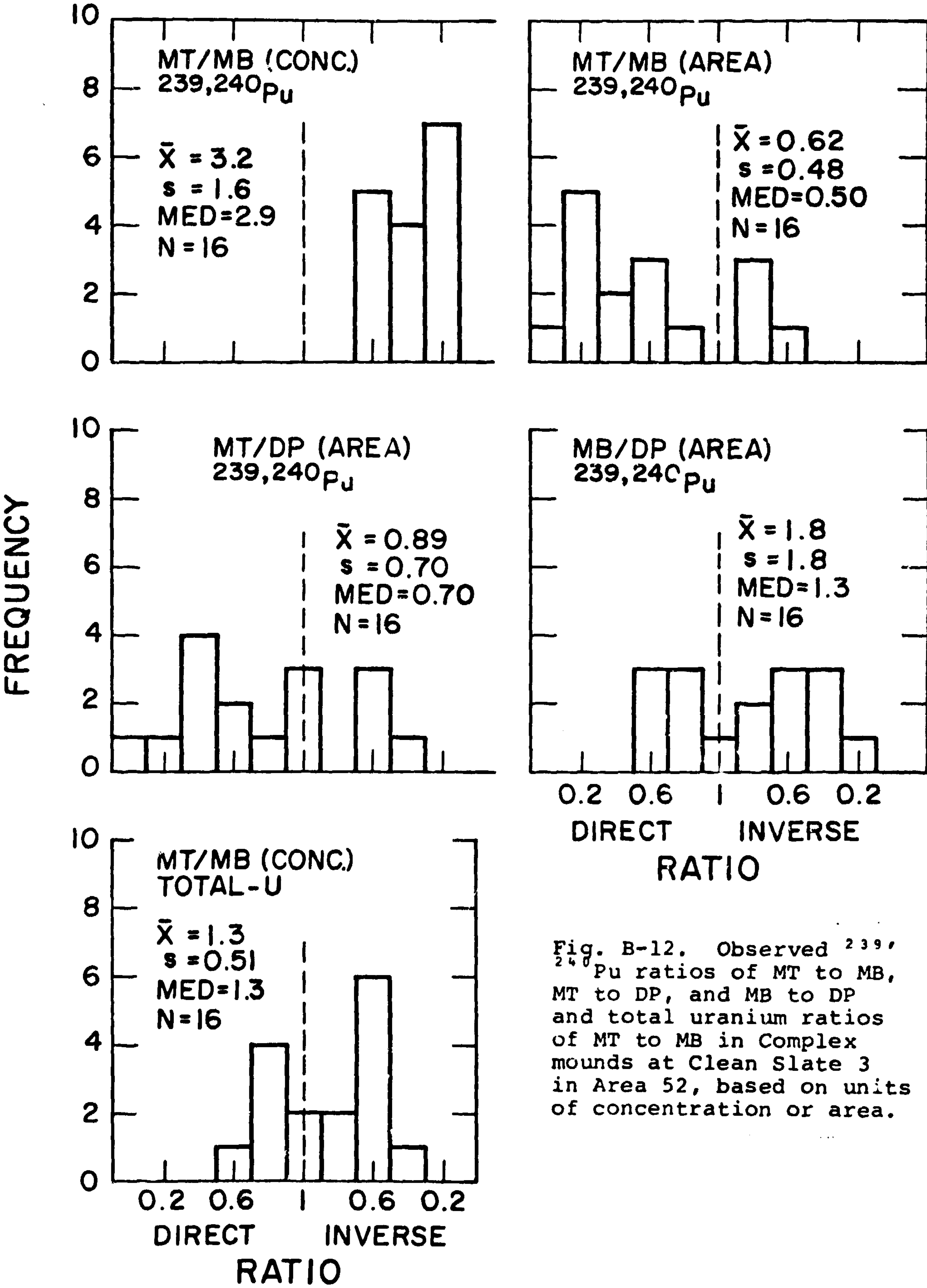


Fig. B-12. Observed $^{239,240}Pu$ ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Complex mounds at Clean Slate 3 in Area 52, based on units of concentration or area.

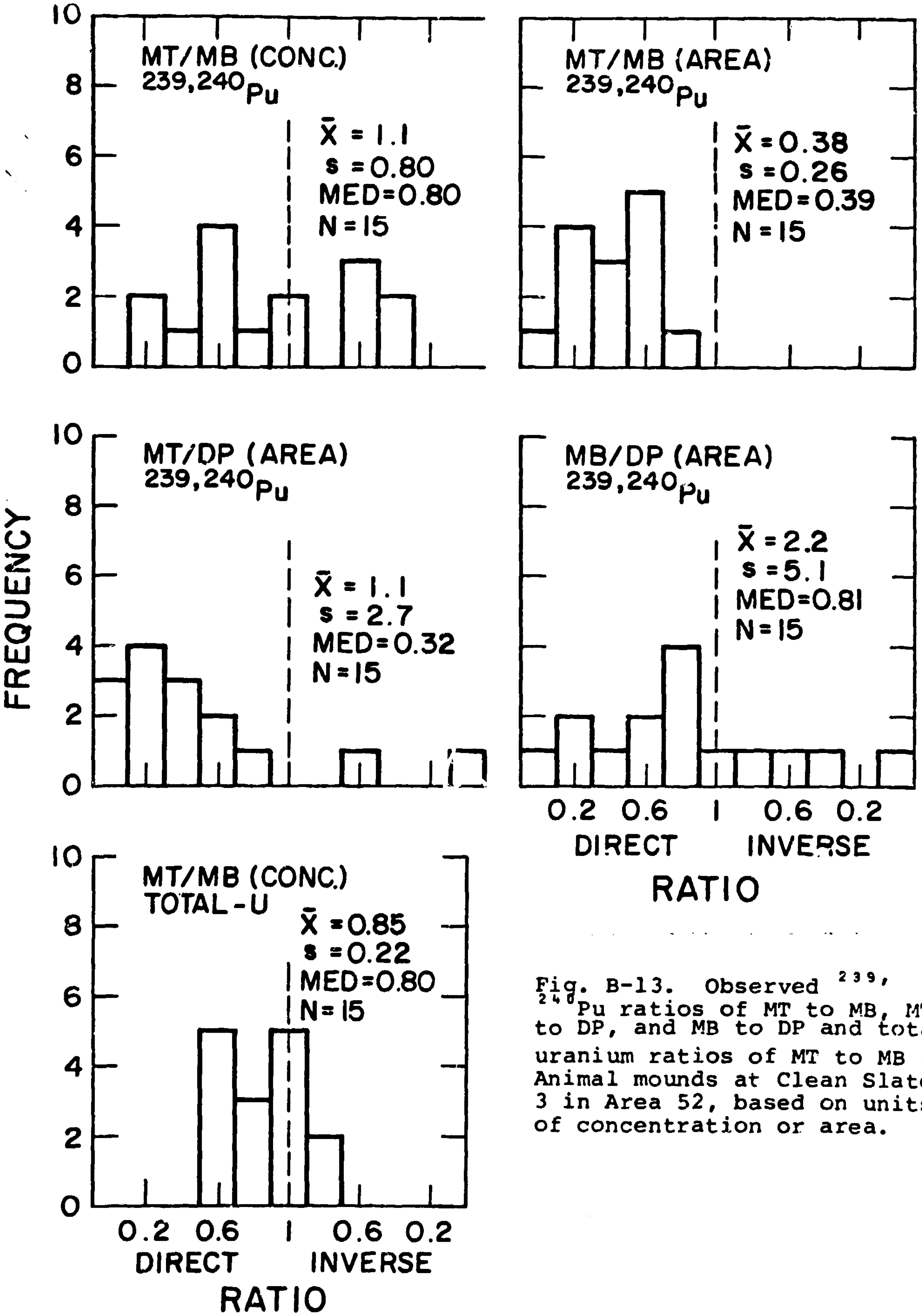


Fig. B-13. Observed ^{239,240}Pu ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Animal mounds at Clean Slate 3 in Area 52, based on units of concentration or area.

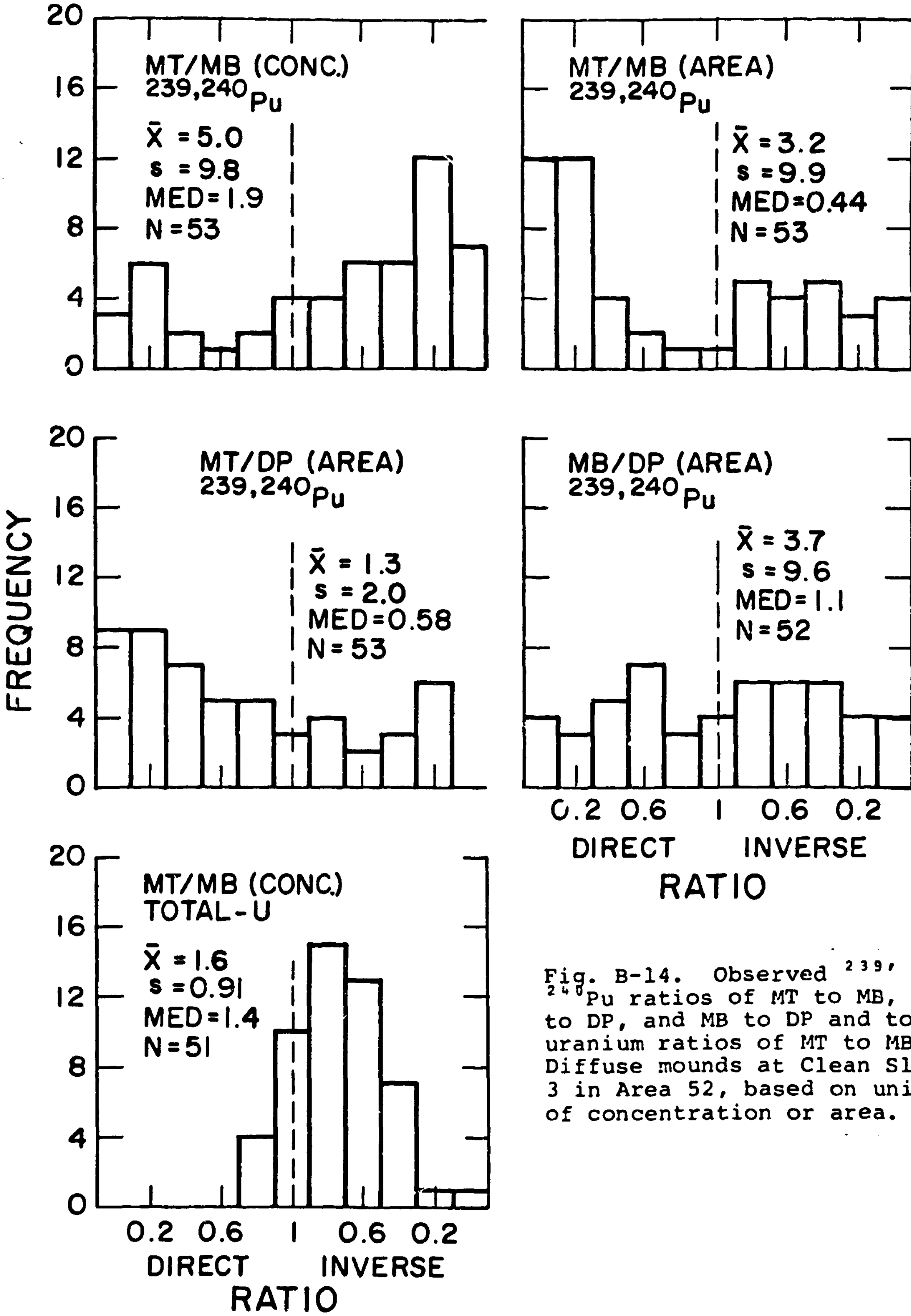


Fig. B-14. Observed $^{239,240}Pu$ ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Diffuse mounds at Clean Slate 3 in Area 52, based on units of concentration or area.

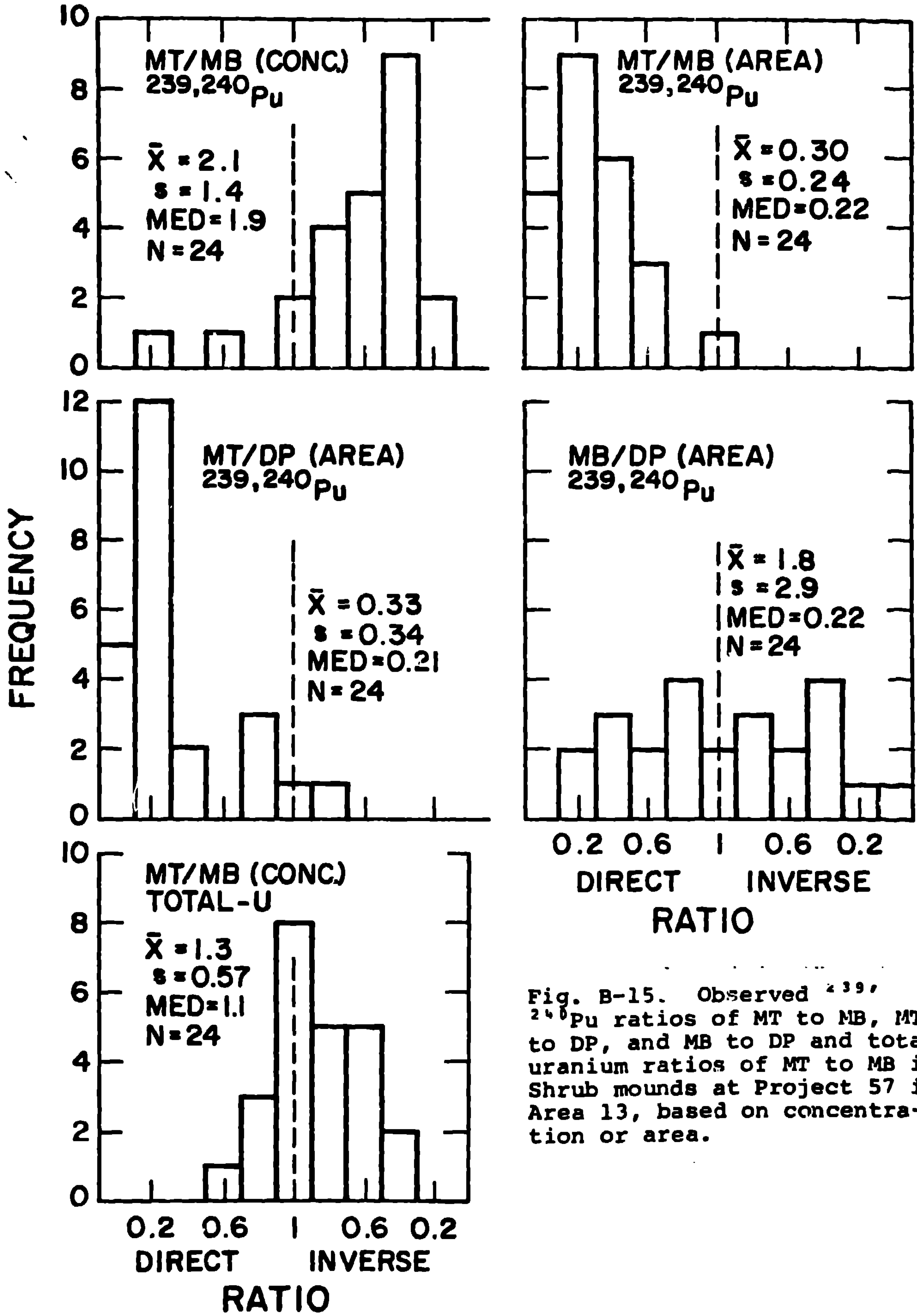


Fig. B-15. Observed $^{239,240}Pu$ ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT to MB in Shrub mounds at Project 57 in Area 13, based on concentration or area.

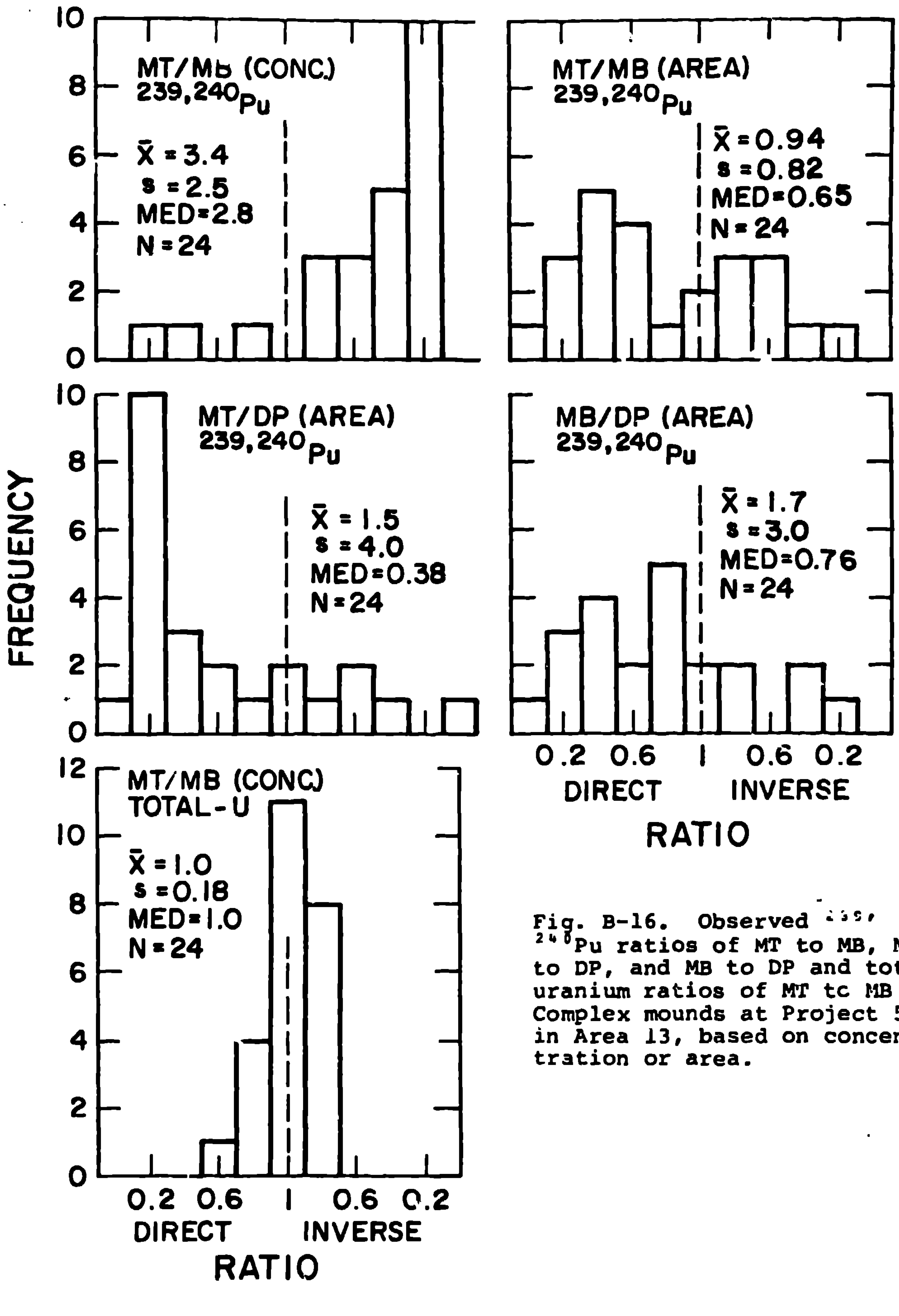


Fig. B-16. Observed ^{239,240}Pu ratios of MT to MB, MT to DP, and MB to DP and total uranium ratios of MT tc MB in Complex mounds at Project 57 in Area 13, based on concentration or area.

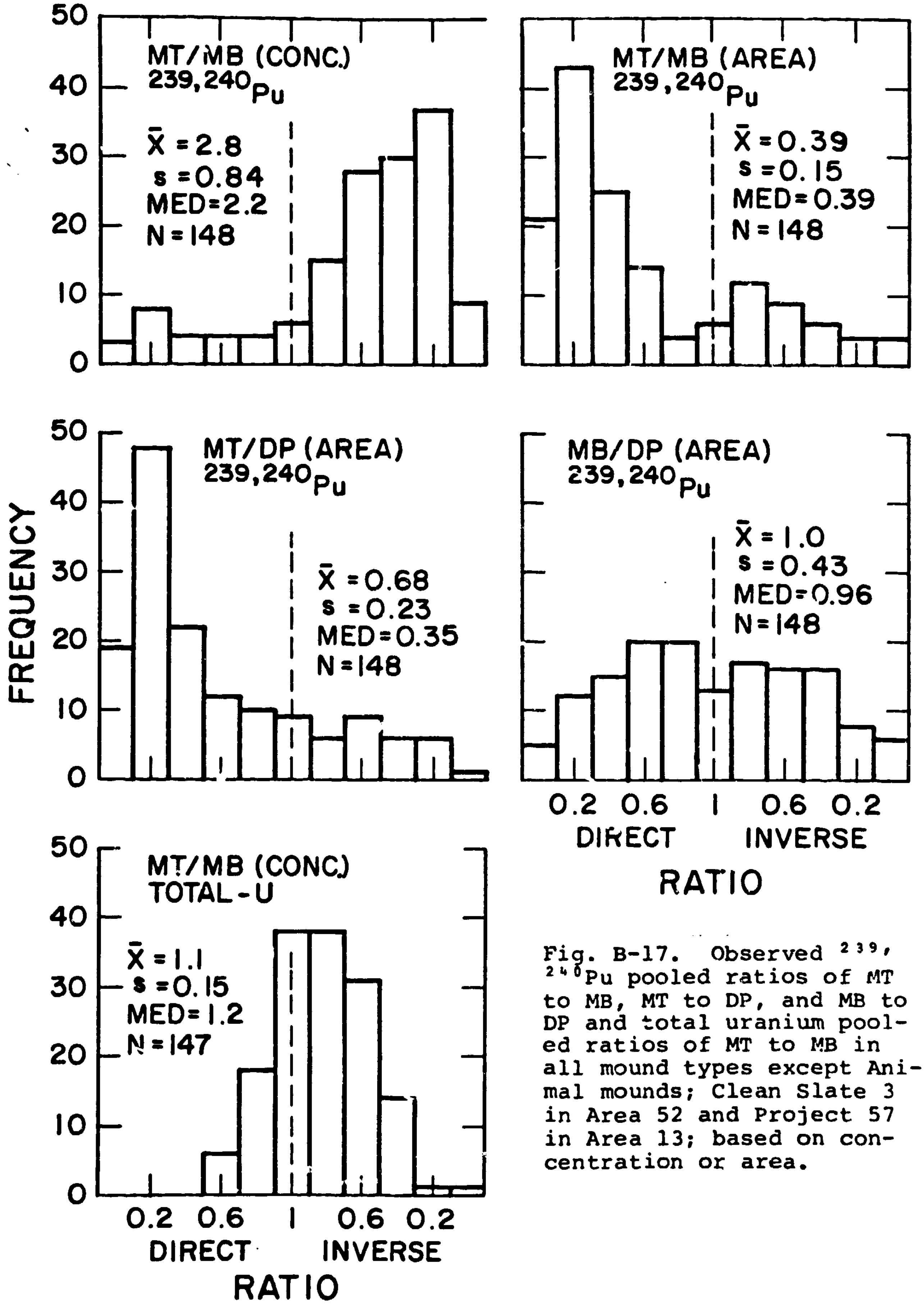


Fig. B-17. Observed ^{239,240}Pu pooled ratios of MT to MB, MT to DP, and MB to DP and total uranium pooled ratios of MT to MB in all mound types except Animal mounds; Clean Slate 3 in Area 52 and Project 57 in Area 13; based on concentration or area.

APPENDIX C

FIDLER MEASUREMENT OBTAINED FOR MOUND STUDY 2

FIDLER[1] measurements were obtained on mounds before and after the mound top was removed and on the adjacent desert pavement sampling location before sampling. The FIDLER (with 5 in. NaI crystal) discriminates gamma radiation in the region of 60 keV (^{241}Am) and 122 keV, using the 122-keV signal as a baseline background correction for the 60-keV signal. All FIDLER measurements were made at a height of 1 ft above the soil surface at each sampling point.

Results of the FIDLER measurements are presented in Figs. C-1 through C-5 for Project 57 in Area 13. Measurements from each of the replicate mound locations in each plot are averages; the arithmetic means are plotted with the ranges. Where one of the observations used to construct the range is below detection, it is noted with a downward pointing arrow. Where all observations of one mound type are below detection, this fact is noted with the word "zero."

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[1]Field instrument for the detection of low energy radiation.

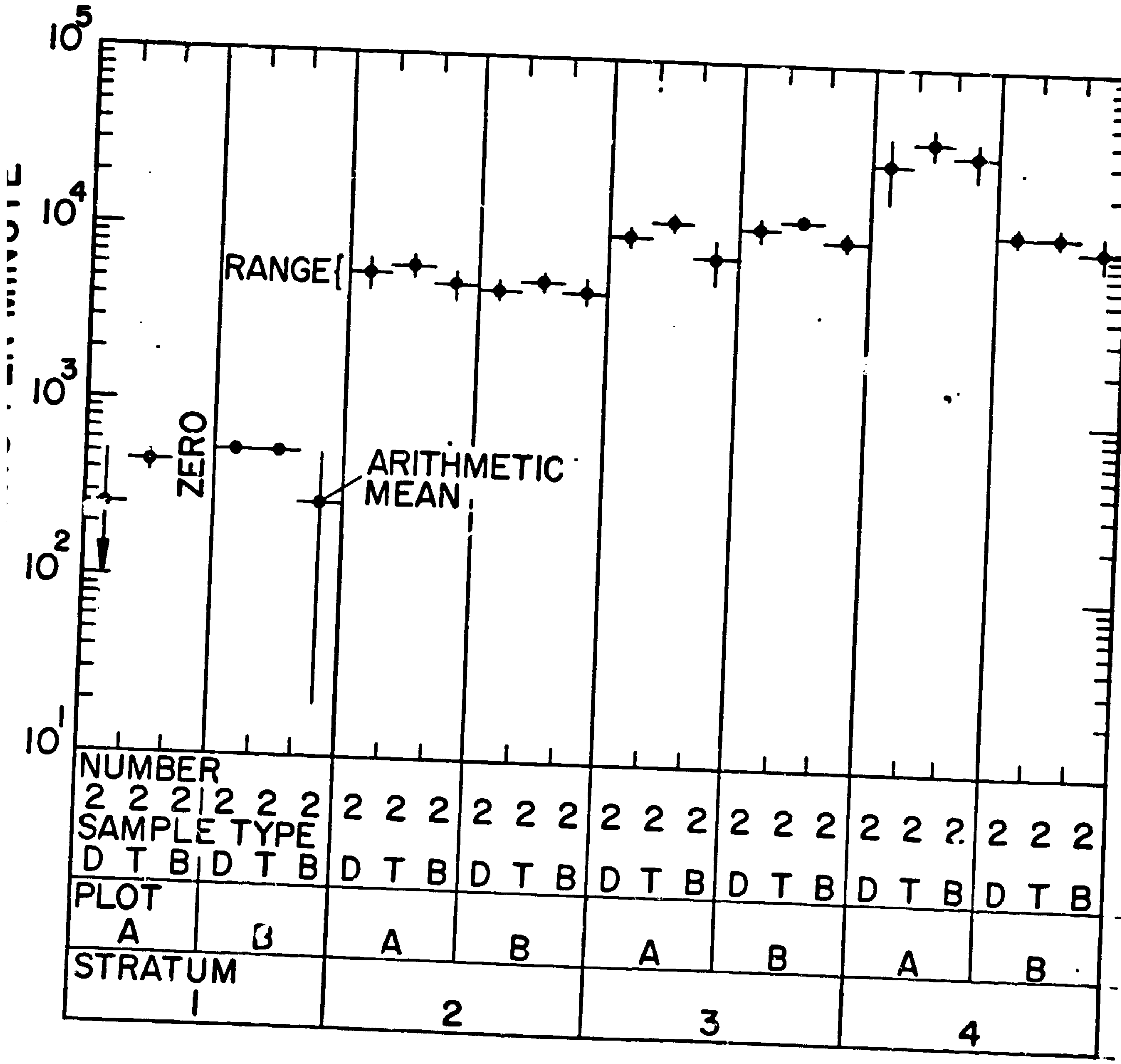

Fig. C-1. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for grass mounds at Clean Slate 3 in Area 52.

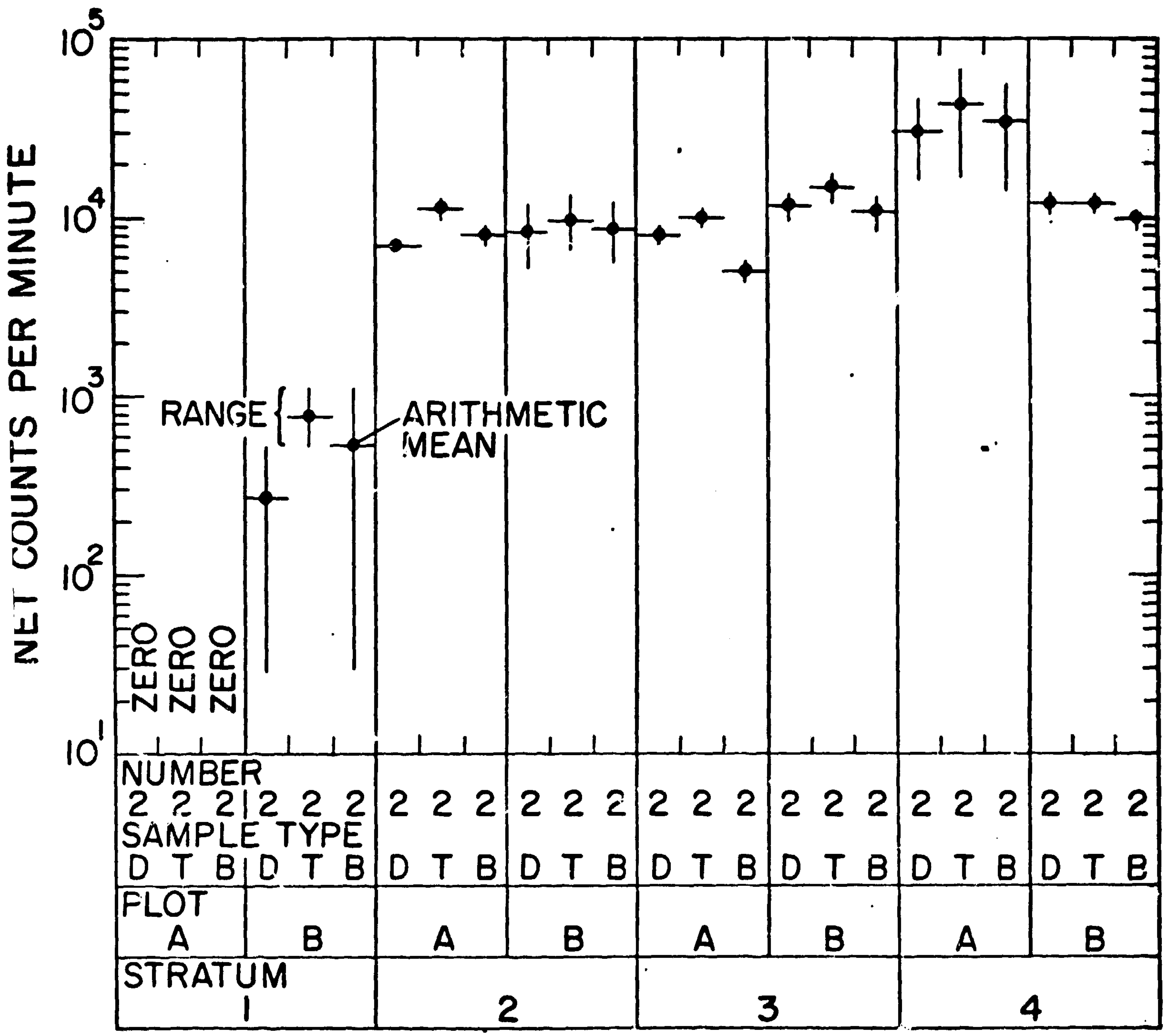

Fig. C-2. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for Shrub mounds at Clean Slate 3 in Area 52.

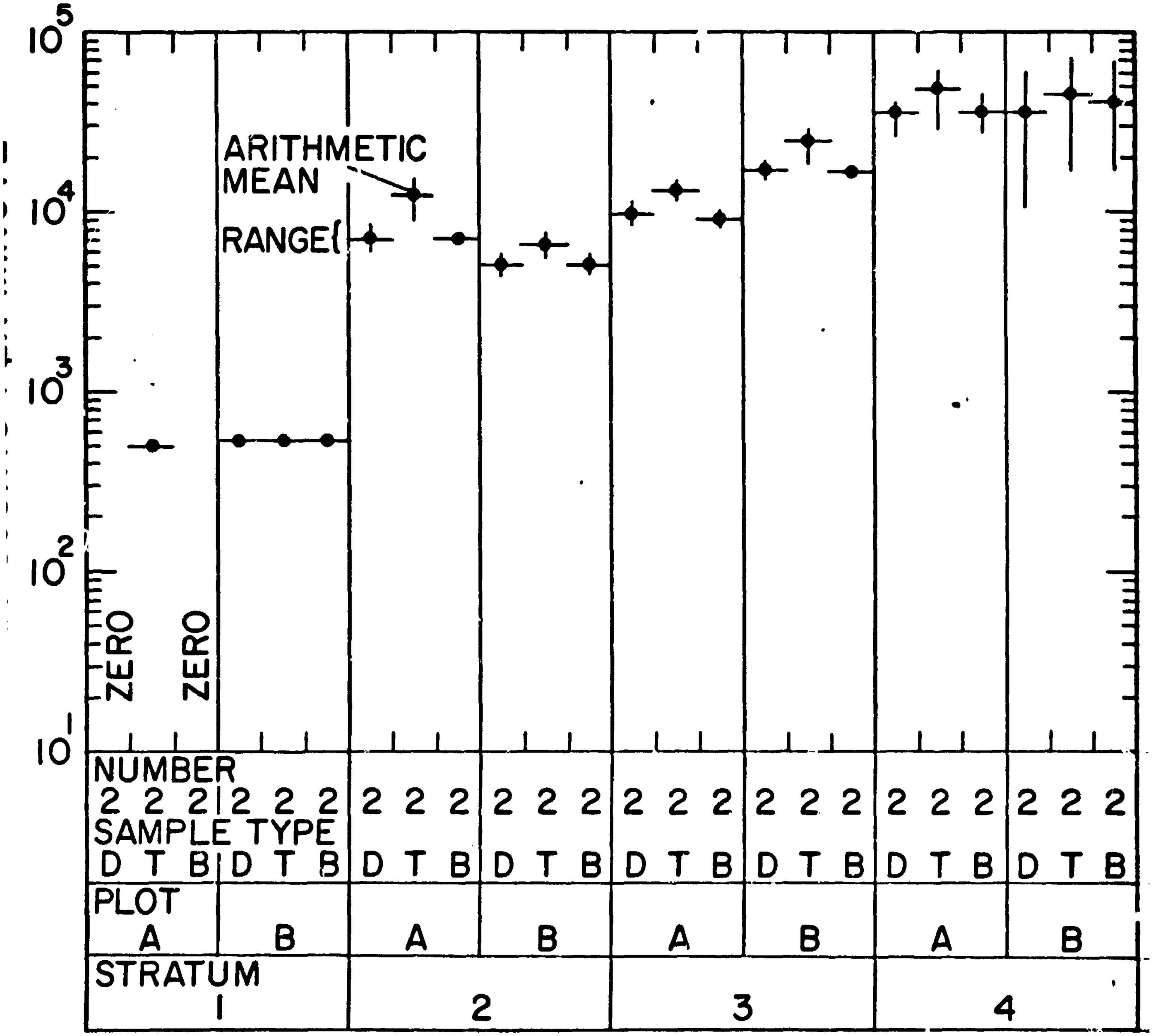

Fig. C-3. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for Complex mounds at Clean Slate 3 in Area 52.

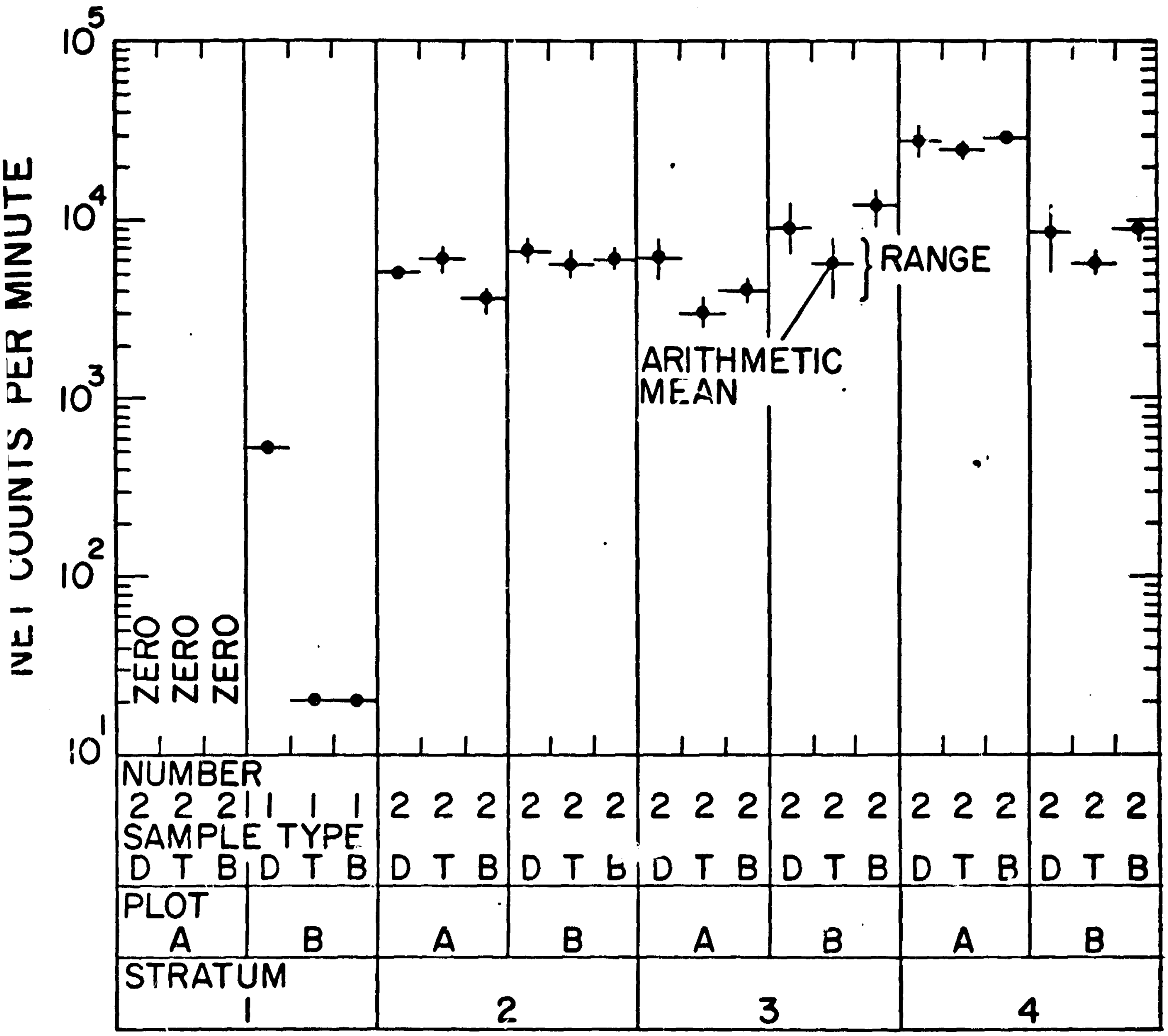

Fig. C-4. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for Animal mounds at Clean Slate 3 in Area 52.

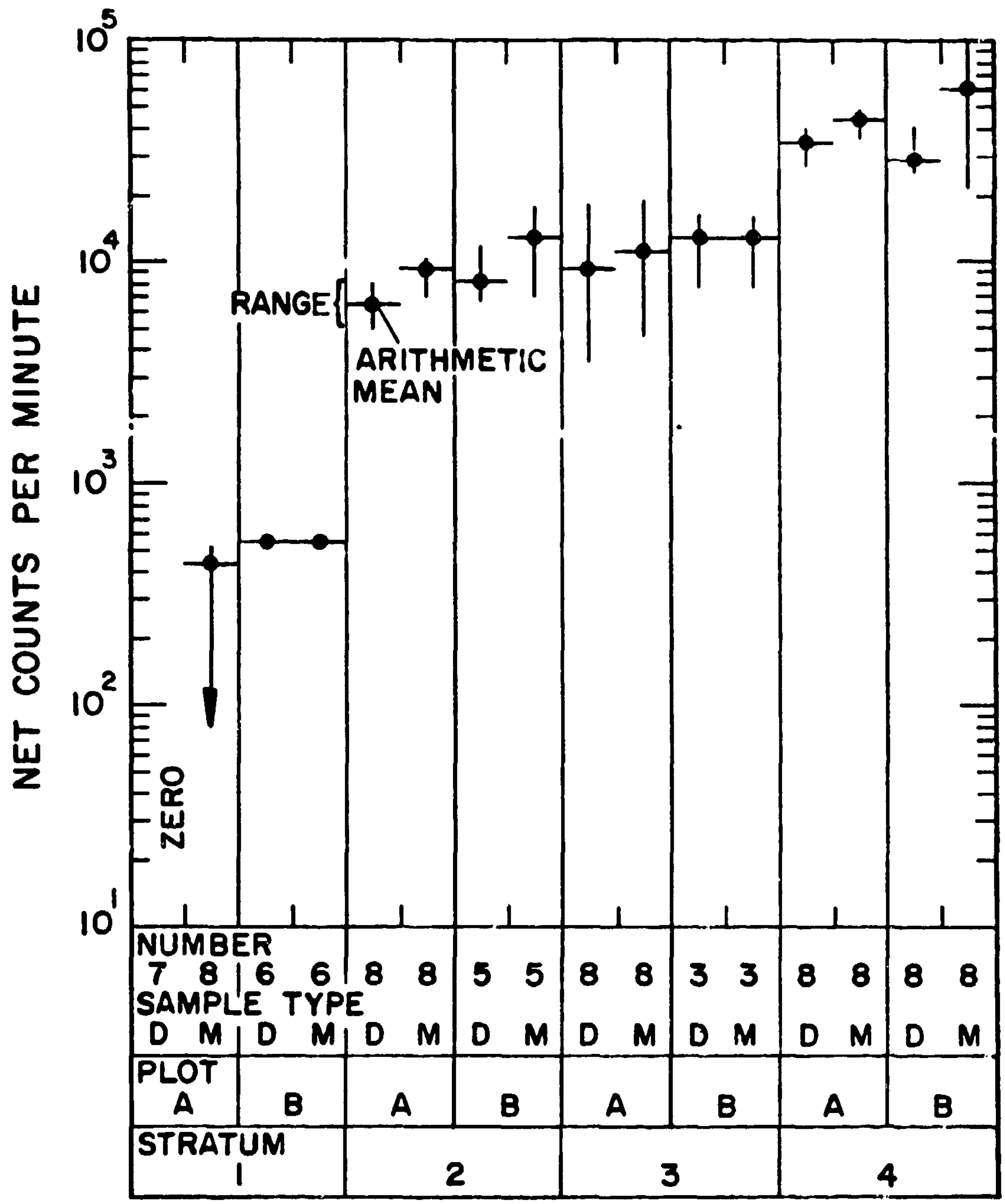

Fig. C-5. FILDER response (^{241}Am, 60-keV Gamma) for mound top (M), and desert pavement (D) for Diffuse mounds at Clean Slate 3 in Area 52.

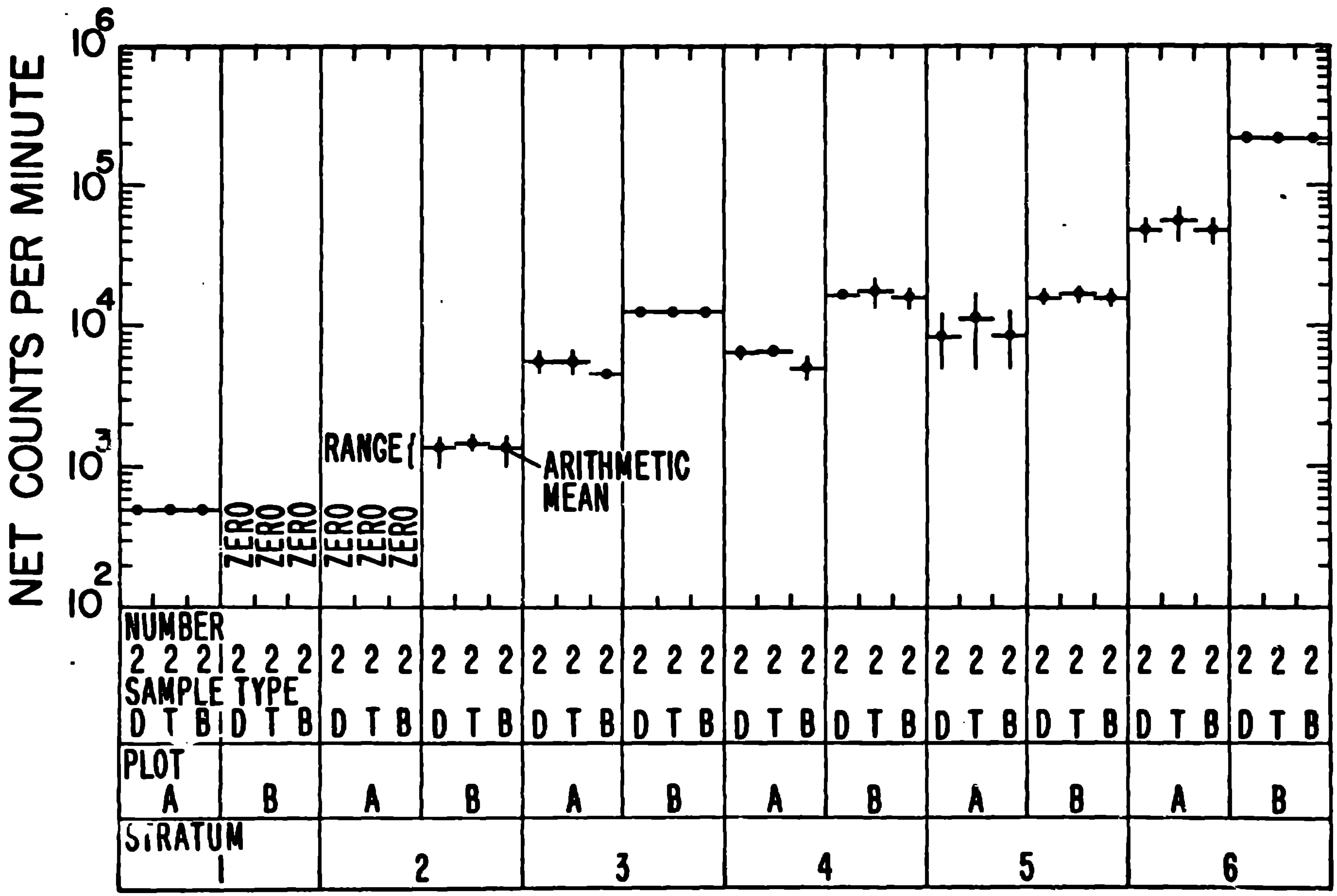

Fig. C-6. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for Shrub mounds at Project 57 in Area 13.

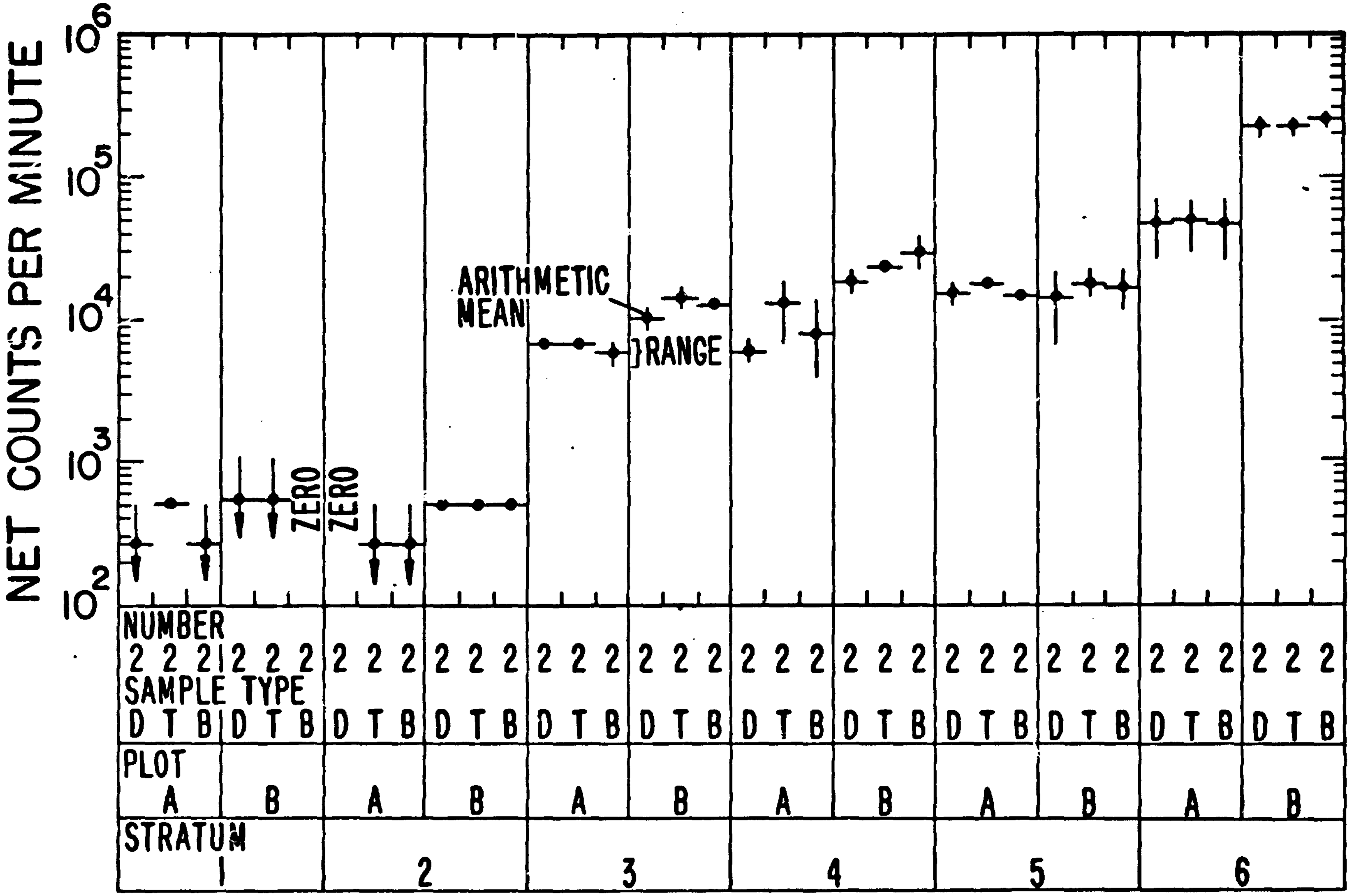

Fig. C-7. FIDLER response (^{241}Am, 60-keV Gamma) for mound top (T), mound bottom (B), and desert pavement (D) for Complex mounds at Clean Slate 3 in Area 52.